INTERNAL NOTE

March 9, 1962 IN-M-P&VE-V-62-1

SATURN C-1 ENVIRONMENTAL CRITERIA

(BLOCK II AND SUBS.)

GEORGE C. MARSHALL SPACE FLIGHT CENTER
Huntsville, Alabama

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Prepared by the

Vehicle Systems Integration Office

VEHICLE SYSTEMS INTEGRATION OFFICE
PROPULSION AND VEHICLE ENGINEERING DIVISION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

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ABSTRACT

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This document presents the natural and the induced environments to be expected during manufacture, test, storage, transportation, launch and flight of the Saturn C-1 vehicles beginning with SA-5 and subsequent. The natural and the induced environments are also presented for launch complex 37 and complex 34.

Author

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INTRODUCTION

This document presents the natural and the induced environments experienced by the Saturn C-1 vehicles (beginning with SA-5 and subsequent) during the manufacture, storage, test, transportation, launch and flight phases. The induced environments are also presented for launch complex 37 for the launch and lift-off phases. These values will apply to complex 34 when it is modified to accommodate the Block II vehicles.

The purpose of this document is to present a common set of environmental criteria that can be used by all design organizations as a basis for designing and testing components located in various Saturn vehicle zones and launch complex areas. The data presented is preliminary and based on the latest available information. Revisions will be made as missing and/or better defined information becomes available.

The vehicle has been divided into a number of zones. The environments for the vehicle test, launch and flight phases are presented on a zone basis. The environments for the manufacture, storage, and transportation phases are presented on a stage basis.

ORGANIZATION OF WORK

This manual is divided into four (4) sections. Each section contains its own table of contents, list of tables and list of illustrations. They are as follows:

SECTION I - GENERAL

SECTION II - NATURAL ENVIRONMENTS

SECTION III - VEHICLE INDUCED ENVIRONMENTS

SECTION IV - LAUNCH COMPLEX INDUCED ENVIRONMENTS

SECTION I

GENERAL

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SECTION I

GENERAL

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SECTION I

GENERAL

1.1 ENVIRONMENTS

The environment is the aggregate of all conditions and influences which affect the operation of the vehicle systems and components. The natural and the induced environments are considered in this document.

1.1.1 Natural Environments - The natural environment consists of those conditions that exist in the earth's atmosphere from sea level to an altitude of 300 kilometers and on land and water surfaces in California, Panama Canal Zone, Gulf of Mexico and Southeastern United States.

1.1.2 Induced Environments - The induced environments are those conditions of shock, vibration, temperature, etc., exclusive of the natural environment to which the vehicle would be exposed. The induced environments include handling and operational shock and vibration loads, aerodynamic heating, flight accelerations, acoustic vibrations, etc.

1.2 PROGRAM PHASES

1.2.1 Manufacturing Phase - The manufacturing phase is that period of time beginning with the initial fabrication and assembly of each stage and the instrument unit major structural component. It extends thru the final installation of the stage and instrument unit.

1.2.2 Test Phase - The testing phase is that period of time during which all tests are performed on the vehicle stages and components. It includes dynamic and static testing of the vehicle stages.

1.2.3 Storage Phase - The storage phase is that period of time during which the assembled vehicle stages, instrument unit, and components are located within permanent shelters or containers.

1.2.4 Transportation Phase - The transportation phase is that period of time during which the vehicle stages and components are moved from one site to another. This period also includes erection and removal of the vehicle stages at the various sites. Transportation during this phase can be by land, air, rivers, gulf, oceans and inland waterways using land transporters, ocean going barges and ships, aircraft and lifting cranes.

1.2.5 Launch Phase - The launch phase is that period of time from installation of the S-I stage on the launch pedestal until vehicle lift-off.

1.2.6 Flight Phase - The flight phase is that period of time from vehicle lift-off (release of the holddown arms) until S-IV stage cutoff or separation of the S-IV stage from the spacecraft. Vehicle lift-off acceleration is included in this phase.

1.2.7 Recovery Phase - Not applicable.

1.3 VEHICLE CONFIGURATION

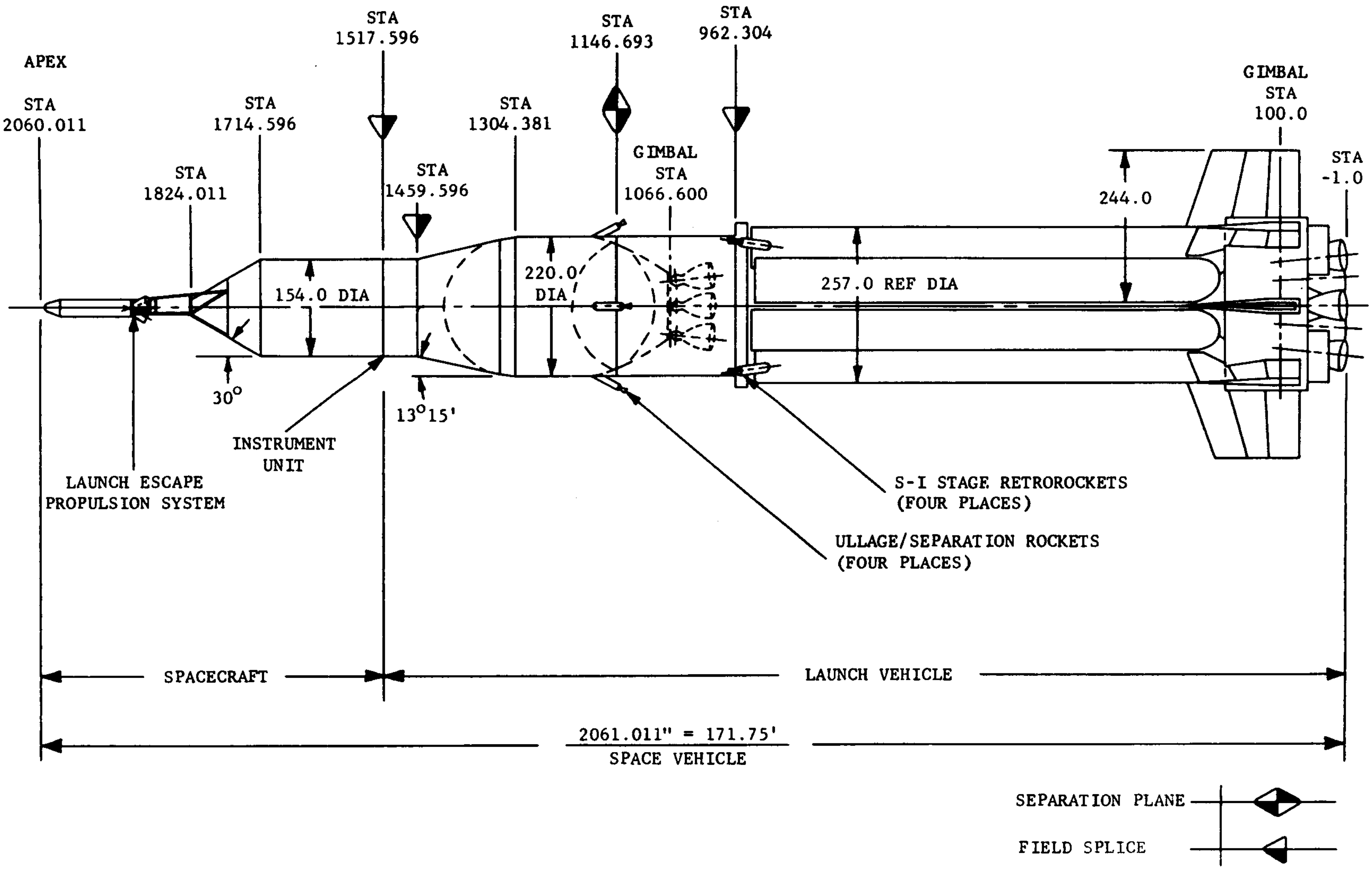
The SATURN C-1 vehicles consist of the live S-I stage with 8 clustered 188,000 pound thrust H-1 rocket engines, the live S-IV stage with 6 clustered 15,000 pound thrust RL10-A-3 rocket engines, an instrument unit and spacecraft (see fig. 1.1).

The S-I stage has nine propellant tanks, one center Lox tank and 4 Lox and 4 fuel tanks mounted circumferentially around the center Lox tanks. The S-I stage is powered by eight H-1 engines that use Lox and RP-1. Each engine has a nominal sea level thrust of 188,000 pounds and a nominal sea level specific impulse of 255.5 lb sec/lb.

The S-IV stage is a cylindrical type configuration that is 220 inches in diameter. The S-IV stage is powered by six RL10-A-3 engines that use Lox and LH_2. Each engine has a nominal vacuum thrust of 15,000 pounds and a vacuum specific impulse of 420 lb sec/lb. The stage is loaded with 100,000 pounds of useable propellants.

The instrument unit is located on top of the S-IV stage. It houses the active and the passenger guidance systems and instrumentation, power supplies, antennas, etc. An x-shaped pressurized cylindrical section is contained within the instrument unit.

FIGURE 1.1
TYPICAL SATURN C-1 CONFIGURATION



1.4 VEHICLE ZONES

ZONE 1 Station 124 to Station-1 - This zone includes the area between the firewall and the exit plane of the H-1 engines. The removable and stub fins are not included. They are covered in Zone 4.

ZONE 2 Station 191 to Station 124 - This zone includes the area between the bottom of the cylindrical portion of the 70-inch tanks and the firewall. The removable and stub fins are not included. They are covered in Zone 4.

ZONE 3 Station 246 to Station 191 - This zone includes the area between the propellant tank aft bulkheads and the bottom of the cylindrical portion of the propellant tanks.

ZONE 3-1 Station 246 to Station 191 - This zone includes the area between the fuel tank aft bulkheads and the bottom of the cylindrical portion of the fuel tanks.

ZONE 3-2 Station 235 to Station 191 - This zone includes the area between the 70-inch-diameter lox tank aft bulkheads and the bottom of the cylindrical portion of the lox tanks.

ZONE 3-3 Station 235 to Station 191 - This zone includes the area between the 105-inch-diameter lox tank aft bulkhead and the bottom of the cylindrical portion of the lox tank.

ZONE 4 This zone includes the removable and stub fins.

ZONE 4-1 This zone includes the removable fins.

ZONE 4-2 This zone includes the stub fins.

ZONE 5 Station 914.05 to Station 235 - This zone includes the area between the propellant tanks aft and forward bulkheads.

ZONE 5-1 Station 898.5 to Station 246 - This zone includes the area between the fuel tank aft and forward bulkheads.

ZONE 5-2 Station 914.05 to Station 235 - This zone includes the area between the 70-inch-diameter lox tanks forward and aft bulkheads.

ZONE 5-3 Station 914.05 to Station 235 - This zone includes the area between the aft and forward bulkheads of the center lox tank.

1.4 Cont'd

ZONE 6 Station 939.06 to Station 898.5 - This zone includes the area between the forward end of the propellant tank bulkheads and the forward end of the cylindrical portion of the propellant tanks.

ZONE 6-1 Station 935.4 to Station 898.5 - This zone includes the area between the forward end of the fuel tank bulkheads and the forward end of the cylindrical portion of the fuel tanks.

ZONE 6-2 Station 939.06 to Station 914.05 - This zone includes the area between the end of the 70-inch-diameter lox tank forward bulkheads and the forward end of the cylindrical portion of the lox tanks.

ZONE 6-3 Station 939.06 to Station 914.05 - This zone includes the area between the end of the 105-inch-diameter lox tank forward bulkhead and the forward end of the cylindrical portion of the lox tank.

ZONE 7 Station 962.304 to Station 941.304 - This zone includes the spider beam.

ZONE 8 Station 1146.693 to Station 962.304 - This zone includes the internal and external areas of the S-IV aft interstage section between the top of the spider beam and the S-IV separation plane.

ZONE 9 This zone includes the area between the engine nozzle exit plane and the engine gimbal plane.

ZONE 10 Station 1066.600 to Station 1146.693 - This zone includes the area between the engine gimbal plane and the intersection of the engine thrust structure with the lox tank aft bulkhead.

ZONE 11 Station 1211.630 to Station 1084.600 - This zone includes the lox tank area between the forward and aft bulkheads.

ZONE 12 Station 1414.380 to Station 1146.693 - This zone includes the internal LH_2 tank area between the forward LH_2 spherical bulkhead and the intersection of the engine thrust structure with the aft common bulkhead.

ZONE 13 Station 1304.38 to Station 1146.693 - This zone includes the external areas between the S-IV separation plane and the intersection of the forward interstage and the forward LH_2 spherical bulkhead.

1.4 Cont'd

ZONE 14 Station 1459.596 to Station 1304.38 - This zone includes the area between the intersection of the forward S-IV interstage and the forward LH_2 spherical bulkhead and the instrument unit field splice.

ZONE 15 Station 1517.596 to Station 1459.596 - This zone consists of the areas between the instrument unit-payload field splice and the instrument unit-S-IV field splice.

ZONE 16 Station 2060.011 to Station 1517.596 - This zone includes the areas forward of the instrument unit-payload field splice.

FIGURE 1.2
S-I STAGE ZONES

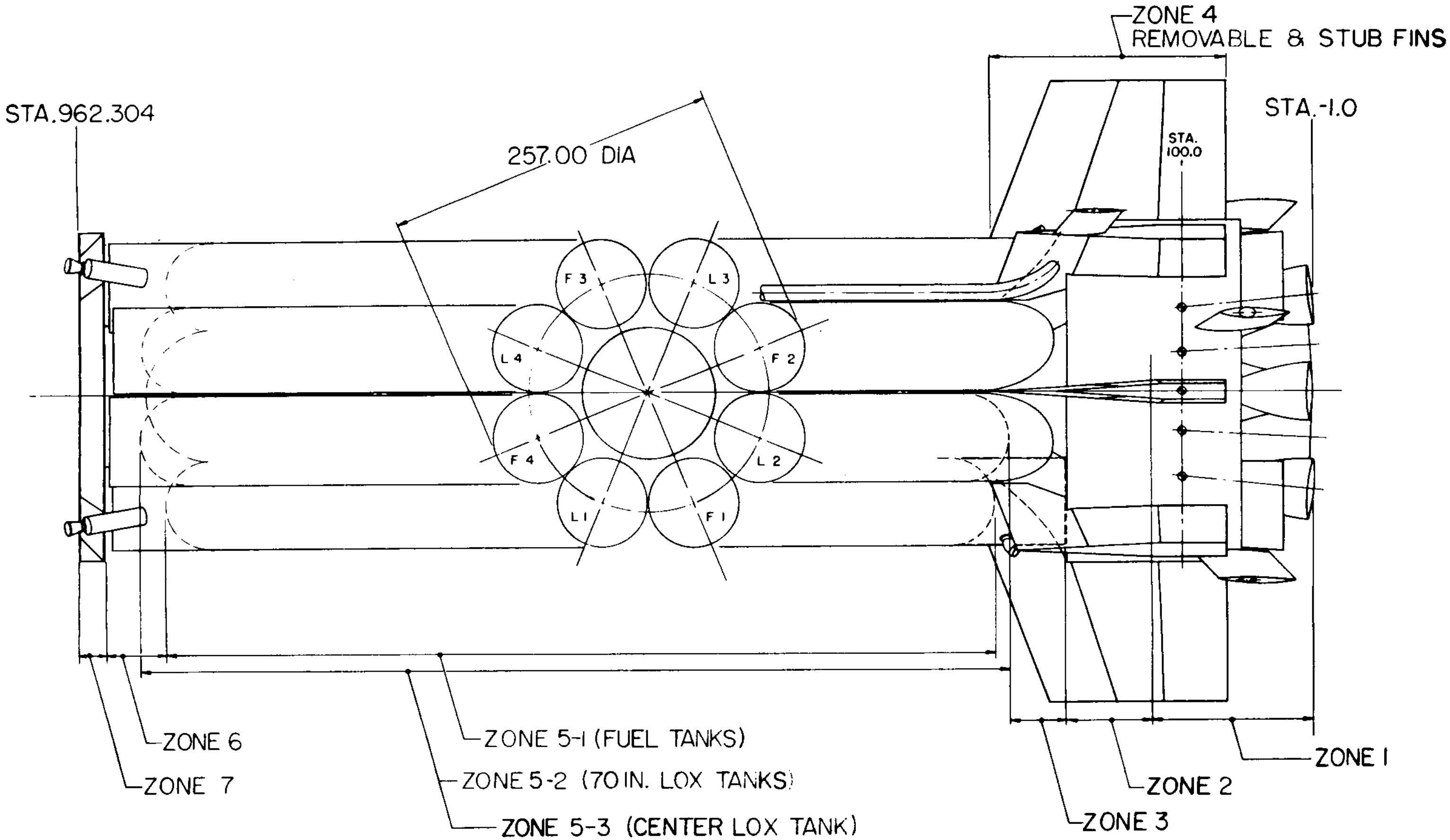


FIGURE 1.3
S-IV STAGE ZONES

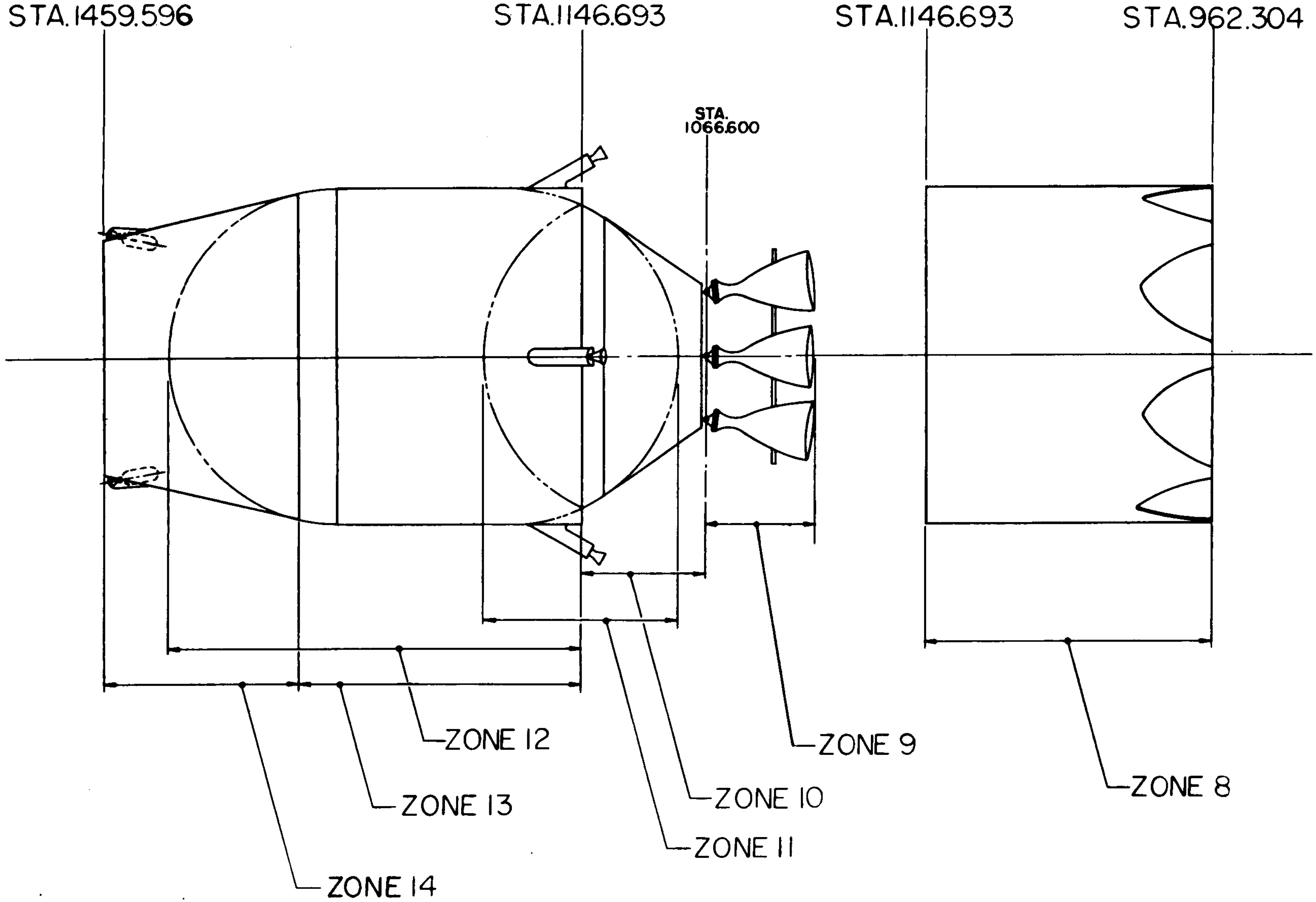
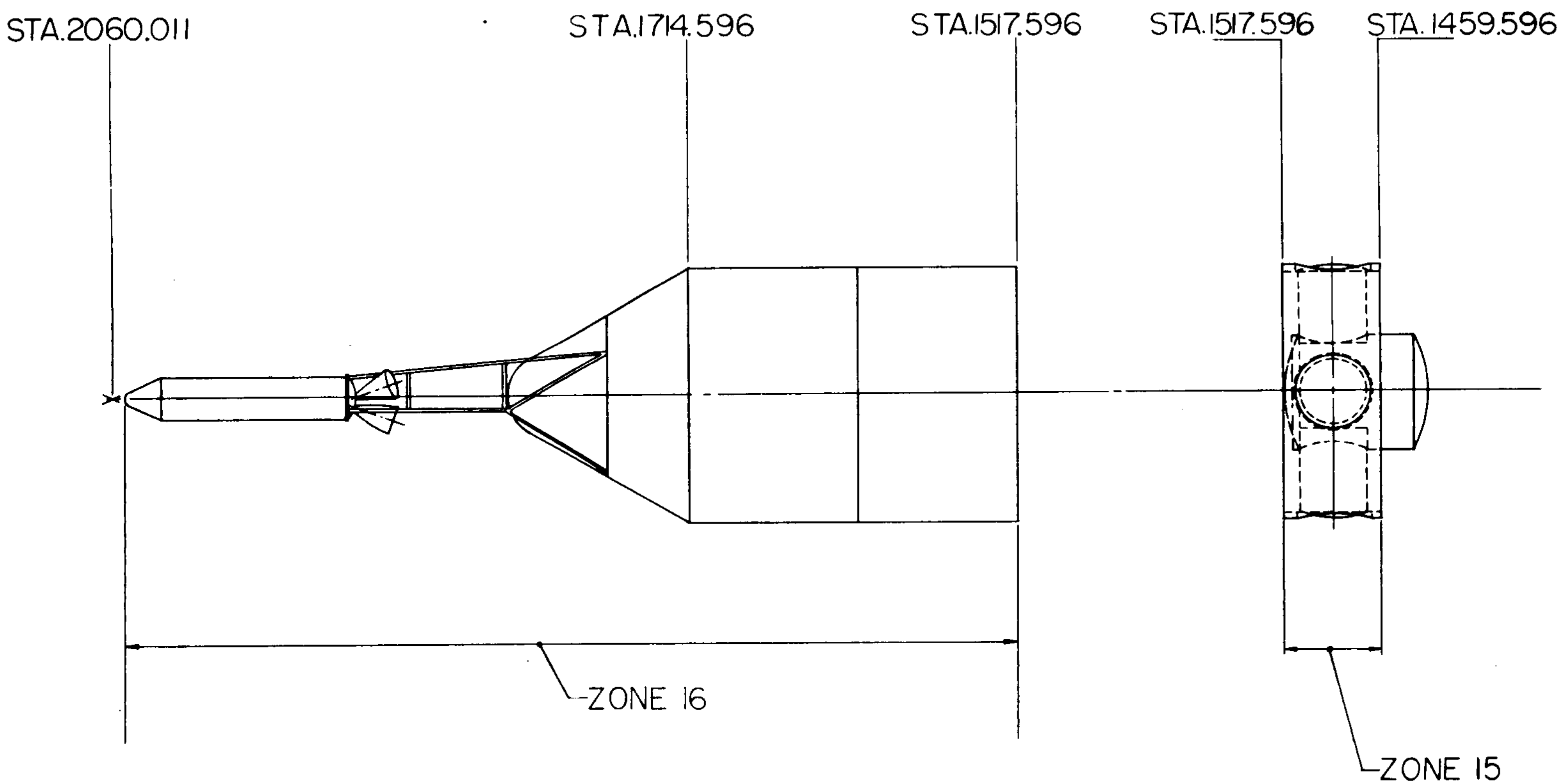


FIGURE 1.4
INSTRUMENT UNIT AND SPACECRAFT ZONES



SECTION II

NATURAL ENVIRONMENTS

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SECTION II

NATURAL ENVIRONMENTS

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SECTION II

2.1 INTRODUCTION

This section includes natural environmental data for use with MSFC space vehicles and associated ground support equipment. These values apply to Saturn C-1 Block II vehicles, and launch complex 34 and 37. The data is applicable only for the geographic areas in which the Saturn vehicle is intended to operate. This section is adapted from MIL-STD-210A, "Climatic Extremes for Military Equipment." MIL-STD-210A, and associated standard atmospheres should be used for geographical areas not included in this document.

2.1.1 Scope - The environmental data presented in this section is applicable for a maximum altitude of 100 kilometers (328,000 feet). For altitudes above 100 kilometers, refer to the ARDC Model Atmosphere. Later revisions will include data for altitudes up to 300 kilometers (984,000 feet).

All values in this section are probable absolute extremes unless otherwise stated.

This section includes the following geographical areas:

a. Huntsville, Alabama

b. River transportation between Huntsville, Alabama (via Tennessee, Ohio, and Mississippi Rivers) and New Orleans, Louisiana.

c. New Orleans Michoud Plant, New Orleans, Louisiana and static test site at adjacent Mississippi area.

d. Gulf transportation between New Orleans, Louisiana (via Gulf of Mexico, and up east coast of Florida) and Cape Canaveral, Florida.

e. Panama Canal transportation between New Orleans, Louisiana and California.

f. Atlantic Missile Range (AMR), Cape Canaveral, Florida.

2.1.2 Definition of Terms

Calm - Calm is the absence of apparent motion of air. If the movement is less than 0.45 m/sec (one mph), the air is considered calm.

Dew Point - Dew point is the temperature to which air must be cooled at constant pressure and constant water-vapor content in order for saturation to occur. Further cooling, below the dew point, normally results in release of water in the form of dew, rain, or snow.

2.1.2 Cont'd

Humidity, Absolute - Absolute humidity is the mass of water vapor present in a unit volume, i.e., the density of the water vapor content.

Humidity, Relative - Relative humidity is the ratio of the actual amount of water vapor in a given volume to the amount of water vapor that the same volume at the same temperature would hold if saturated. Values given are in percent.

Precipitation - Precipitation includes all forms of water particles, whether liquid or solid, that fall from the atmosphere and reach the ground, i.e., drizzle, rain, snow, hail, snow pellets (graupel), snow grains, ice crystals, and ice pellets (sleet).

Pressure, Atmospheric - Atmospheric pressure is the pressure exerted by the weight of a column of air lying directly above the area in question. It is expressed as force per unit area.

Radiation, Solar - Solar radiation is the total electromagnetic radiation energy emitted by the sun. About 99.9 percent of this energy is within the wave length interval from 0.15 to 4.0 microns. About one half of the total energy in the solar beam is contained within the visible spectrum (0.4 to 0.7 microns). Most of the remaining energy is in the near infrared (0.7 to 4.0 microns), with a small portion in the ultraviolet spectrum (0.15 to 0.4 microns). In general, solar radiation data includes diffuse sky radiation (about 15 percent of the total radiation) measured on a horizontal surface. Solar radiation values given in this document are intensities of direct solar and diffuse sky radiation, measured on a surface normal to the sun.

Snow - Snow includes all forms of frozen precipitation except hail i.e., snow, snow pellets, snow grains, ice crystals and ice pellets.

Temperature, Air - The free air temperature is measured under standard conditions of height, ventilation and radiation shielding. The air temperature is normally measured with liquid-in-glass thermometers in a louvered wooden shelter painted white inside and outside, with the base of the shelter normally at a height of four feet above a close-cropped grass surface (Ref. 3, p. 59).

Temperature, Radiation - Radiation temperature is the temperature of a radiating black body determined by Wien's displacement law: i.e.,

$$T_R = \frac{w}{\lambda max}$$

where T_R = Radiation Temperature in degrees Kelvin

w = Wien's displacement constant = 0.2898 cm°K

λmax = The wave length corresponding to the maximum radiation energy.

2.1.2 Cont'd

Temperature, Surface - Surface temperature is the temperature that a surface will assume when exposed to air temperature and solar radiation within the wavelength interval of 0.15 to 4.0 microns. Surface temperature extremes depend on the surface emissivity and angle of the surface to the line between the surface and the radiation source such as the sun or sky.

Water Vapor - Water vapor is water in the gaseous state.

Wind Distribution with Height - The power law equation (Ref. 4) is used to compute steady state and peak wind distribution with height.

$$V = V_1 \left(\frac{Z}{Z_1}\right)^p$$

where: V_1 is the wind speed at reference height Z_1

V is the wind speed at height Z

p is a nondimensional quantity determined empirically.

$p = 0.20$ when the 3 meter (9.8 feet) steady state wind is less than 15 m/sec (33.5 mph)

$p = 0.17$ when the 3 meter (9.8 feet) steady state wind is between 15 (33.5 mph) and 20 m/sec (44.7 mph)

$p = 0.15$ when the 3 meter (9.8 feet) steady state wind is greater than 20 m/sec (44.7 mph)

Wind, Peak - Peak wind is the steady state wind multiplied by a gust factor of 1.4. The gust shape for the highest wind conditions given in paragraph 2.4 resembles a sharp wedge with a linear increase to the peak wind in two (2) seconds and then linear decay to the steady state value in two (2) seconds. For the lower wind conditions the wedge has less amplitude, but the same period.

Wind, Maximum Peak - Maximum peak wind is the highest wind expected including hurricane or severe thunderstorm conditions. Since the wind distribution with height does not apply for extreme wind conditions, this wind will be the same over the entire altitude range.

Winds, Steady State - A steady state wind is the average wind speed over a period of one (1) minute. This is the basic data normally recorded at weather stations with cup-type or propeller-type anemometers. Data for steady state winds in this report do not include hurricane or severe thunderstorm (squall) conditions.

2.1.3 Conversion of Units

Solar Radiation Intensity - One gram calorie per square centimeter (gm cal/cm^2) equals 64.82 watts per square foot (watts/ft^2) equals 221.2 BTU/ft^2hr.

Absolute Humidity - One gram per cubic meter (gm/m^3) equals 0.4370 grains per cubic foot (gr/ft^3).

Wind Speed - One meter per second (m/sec) equals 2.24 miles per hour (mph) equals 1.94 knots.

Atmospheric Pressure - One millibar (mb) equals 1.0×10^3 dynes per square centimeter (dynes/cm^2) equals 1.45×10^{-2} pounds per square inch (lb/in^2) equals 10.2 kilograms per square meter (kg/m^2).

2.2 TEMPERATURE

2.2.1 Ground Temperature

2.2.1.1 Probable Hot Thermal Extremes - Exposure of a space vehicle to a high air temperature without incoming solar radiation will cause the vehicle to assume a temperature less than the air temperature because of radiation losses. The combination of solar radiation and a high air temperature will cause the space vehicle skin temperature to exceed the air temperature. The temperature reached will be a function of the surface emissivity (surface color). The darker the color, the higher the temperature.

Temperatures measured close to the earth's surface are considerably higher on a clear day with the sun near its zenith than the corresponding standard air temperature (Ref. 6). The heating effect will be highest on a surface that is normal to the sun.

Hot thermal extremes are given as a combination of temperature and solar radiation intensity normal to a surface (about 15% higher than total intensity values given in MIL-STD-210A Ref. 1). The data is as follows:

a. Huntsville, river transportation, Panama Canal and Pacific Missile Range areas.

A twenty four (24) hour cycle of air temperature and solar radiation must be considered (fig. 2.1, p. 2-9) that starts with 10 hours of air temperature at 29°C (85°F) with no solar radiation, followed by five (5) hours of linearly increasing air temperature to 46°C (115°F) with the solar radiation intensity increasing as follows:

(1) One (1) hour of linearly increasing intensity from 0 to 1.20 gram cal/cm^2 (265 BTU/ft^{2}hr).

(2) Two (2) hours of linearly increasing intensity from 1.20 gm cal/cm^2 (265 BTU/ft^{2}hr) to 1.6 gm cal/cm^2 (354 BTU/ft^{2}hr).

(3) Two (2) hours of linearly increasing intensity from 1.6 gm cal/cm^2 (354 BTU/ft^{2}hr) to 1.85 gm cal/cm^2 (409 BTU/ft^{2}hr).

Then consider four (4) hours of constant conditions at the maximum air temperature and solar radiation intensity. Finally consider five (5) hours of linearly decreasing air temperature to 29°C (85°F) and solar radiation intensity decreasing in reverse order as given in a (3), a (2) and a (1) above to zero (0) intensity. The steady state wind speed from the surface to 10 meters (32.8 ft.) should be taken as 1 m/sec (2.2 mph) to 3 m/sec (6.8 mph) for the 24 hour period.

2.2.1.1 Cont'd

b. New Orleans, Gulf transportation and Atlantic Missile Range Areas.

A twenty four (24) hour cycle of air temperature and solar radiation must be considered (fig. 2.2, p. 2-10) that starts with 10 hours of air temperature at 24°C (75°F) with no solar radiation, followed by five (5) hours of linearly increasing air temperature to 41°C (106°F) with the solar radiation intensity increasing as follows:

(1) One (1) hour of linearly increasing intensity from 0 to 1.1 gm cal/cm^2 (243 BTU/ft^{2}hr).

(2) Two (2) hours of linearly increasing intensity from 1.1 gm cal/cm^2 (243 BTU/ft^{2}hr) to 1.5 gm cal/cm^2 (332 BTU/ft^{2}hr).

(3) Two (2) hours of linearly increasing intensity from 1.5 gm cal/cm^2 (332 BTU/ft^{2}hr) to 1.6 gm cal/cm^2 (354 BTU/ft^{2}hr).

Then consider four (4) hours of constant conditions at the maximum air temperature and solar radiation intensity. Finally consider five (5) hours of linearly decreasing air temperature to 24°C (75°F) and solar radiation intensity decreasing in reverse order as given in b (3), b (2), and b (1) above to 0 intensity. The steady state wind speed from the surface to 10 meters (33 ft) should be taken as 1 m/sec (2.2 mph) to 3 m/sec (6.8 mph) for the 24 hour period.

2.2.1.2 Probable Cold Thermal Extreme - The actual surface temperature that an object will assume when exposed to cold extremes will be a value between the actual air temperature and the radiation temperature of the sky. The minimum air temperature and the radiation sky temperature are given below:

a. Huntsville and river transportation areas

Air temperature	-26°C (-15°F)
Sky radiation temperature	-40°C (-40°F)
Wind	calm
Duration	24 hours

b. New Orleans area

Air temperature	-12°C (+10°F)
Sky radiation temperature	-26°C (-15°F)

2.2.1.2 Cont'd

Wind	calm
Duration	24 hours

c. Gulf transportation, Atlantic Missile Range, Panama Canal transportation and Pacific Missile Range area

Air temperature	-9°C (+16°F)
Sky radiation temperature	-23°C (-10°F)
Wind	calm
Duration	24 hours

2.2.1.3 Thermal Shock - Maximum expected thermal shock for all areas is a 10°C (18°F) increase of air temperature in one hour and an increase in solar radiation intensity from 0.5 gm cal/cm^2 (111 BTU/ft^{2}hr) to 1.85 gm cal/cm^2 (409 BTU/ft^{2}hr) . Similarly, the reverse change takes place during one hour, i.e., a 10°C (18°F) decrease in air temperature and a decrease in solar radiation intensity from 1.85 gm cal/cm^2 (409 BTU/ft^{2}hr) to 0.5 gm cal/cm^2 (111 BTU/ft^{2}hr).

2.2.2 Temperature at Altitude - The division of thermal extremes at altitude into hot, cold and thermal shock, would be an artificial division that would not serve any definite purpose. The information given below when used with the vehicle flight characteristics will give the required thermal extremes. References 17 and 18 contain the current acceptable information on median, maximum and virtual temperatures. Virtual temperature are used for all speed of sound computations and for any computations where a mixture of moist and dry air is involved.

Solar radiation environment will depend on the time and local conditions at launch. The solar radiation will vary with height in accordance with the following equation:

$$I_H = I_S + (2.0 - I_S)\left(1 - \frac{\rho_H}{0.121}\right)$$

where: I_H = Intensity of solar radiation normal to surface at required height in gm cal/cm^2

I_S = Intensity of solar radiation normal to surface at earth's surface in gm cal/cm^2 assuming clear conditions. Values for I_S can be used from para. 2.2.1.

ρ_H = Atmospheric density at required height in kp sec^2/m^4 (see Ref. 17, Table III, PP. 23-29)

2.2.2 Cont'd

This equation is valid when the vehicle is exposed to solar radiation without atmospheric clouds (i.e., when it reaches a height greater than the top of existing clouds), and while the vehicle is near the earth.

The above equation does not consider the additional solar radiation that may be reflected or radiated from the earth or other planets. The total reflected and radiated radiation could in certain cases be equal to one and one-half times I_H.

FIGURE 2.1
PROBABLE HOT THERMAL EXTREME FOR HUNTSVILLE,
RIVER TRANSPORTATION, PANAMA CANAL TRANSPORTATION,
AND PACIFIC MISSILE RANGE AREAS

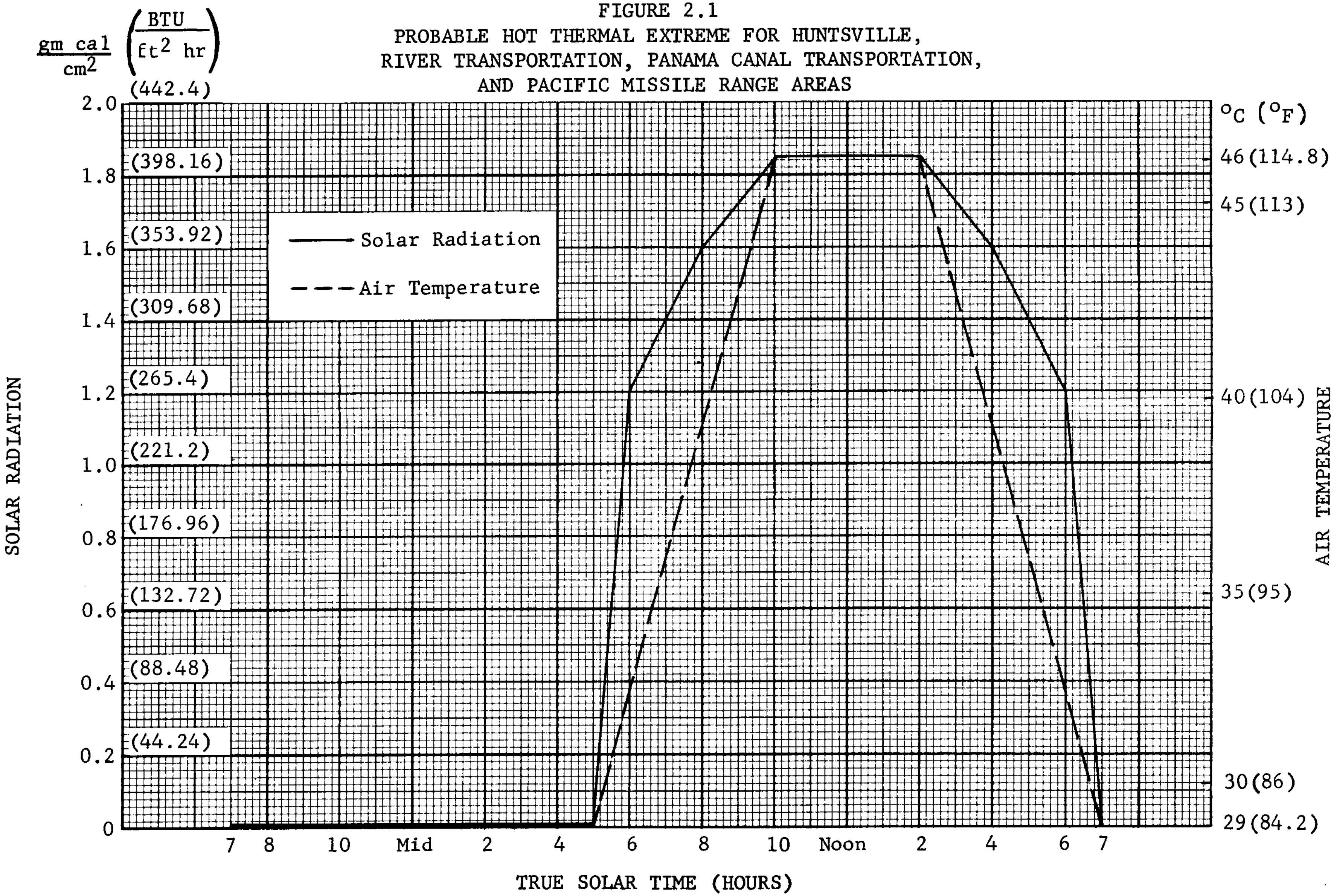
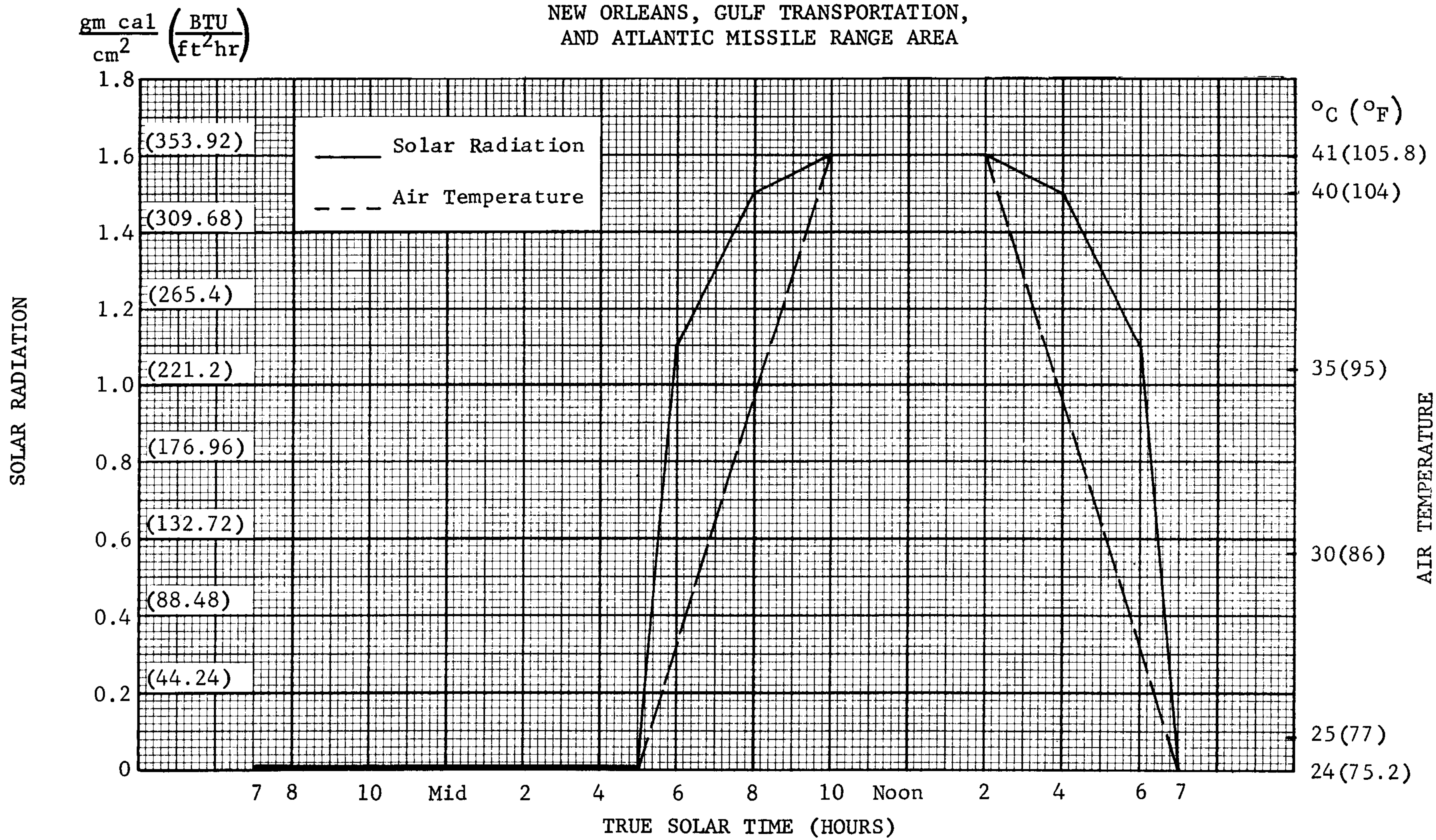


FIGURE 2.2
PROBABLE HOT THERMAL EXTREME FOR
NEW ORLEANS, GULF TRANSPORTATION,
AND ATLANTIC MISSILE RANGE AREA



2.3 ATMOSPHERIC PRESSURES

Mean sea level pressure is 1,013.25 millibars (14.69 psi). Extreme surface atmospheric pressures and the corresponding elevations that these pressures represent at standard atmospheric conditions, are given below. These values are actual station pressures and are not reduced to mean sea level.

a. Huntsville area

	Pressure		Elevation with Standard Atmospheric Conditions (height from mean sea level)	
	mb	psi	meters	feet
Maximum	1016	14.73	-21	-69
Average	988	14.33	202	663
Minimum	948	13.75	532	1745

b. River Transportation areas

	Pressure		Elevation with Standard Atmospheric Conditions (height from mean sea level)	
	mb	psi	meters	feet
Maximum	1041	15.1	-215	-705
Average	1000	14.5	106	348
Minimum	900*	13.1	948	3109

c. New Orleans, AMR, PMR, Panama Canal Transportation and Gulf Transportation areas

	Pressure		Elevation with Standard Atmospheric Conditions (height from mean sea level)	
	mb	psi	meters	feet
Maximum	1041	15.1	-215	-705
Average	1013	14.69	0	0
Minimum	900*	13.1	948	3109

*During hurricane conditions

2.3 Cont'd

References 17 and 18 contain the current acceptable information on median, maximum and minimum pressures with respect to height.

2.4 WINDS

2.4.1 Ground Winds

ATLANTIC MISSILE RANGE AREA 99.9% PROBABILITY LEVEL							
Height Above Ground		Steady State Wind		Peak Wind		Maximum Peak Wind	
m	ft	m/sec	mph	m/sec	mph	m/sec	mph
3	9.8	11.8	26.4	16.5	37.0		
10	32.8	15.0	33.6	21.0	47.0		
20	65.6	17.3	38.7	24.2	54.2		
30	98.4	18.7	41.9	26.2	58.7		
60	197	21.5	48.2	30.1	67.3		
100	328	23.8	53.3	33.3	74.5		
150	492	25.8	57.8	36.1	80.8	56	125

HUNTSVILLE AREA 99.9% PROBABILITY LEVEL							
Height Above Ground		Steady State Wind		Peak Wind		Maximum Peak Wind	
m	ft	m/sec	mph	m/sec	mph	m/sec	mph
3	9.8	16.8	37.6	23.5	52.6		
10	32.8	20.6	46.1	28.8	64.4		
20	65.6	23.2	51.9	32.5	72.7		
30	98.4	24.8	55.5	34.7	77.6		
60	196.8	28.0	62.6	39.2	87.5		
100	328	30.5	68.2	42.7	95.5		
150	492	32.7	73.1	45.8	102.5	57	128

2.4.2 Winds at Altitudes

FIGURE 2.3
NINETY FIVE PERCENT PROBABILITY OF OCCURRENCE WIND SPEED
PROFILE ENVELOPE
CAPE CANAVERAL, FLORIDA

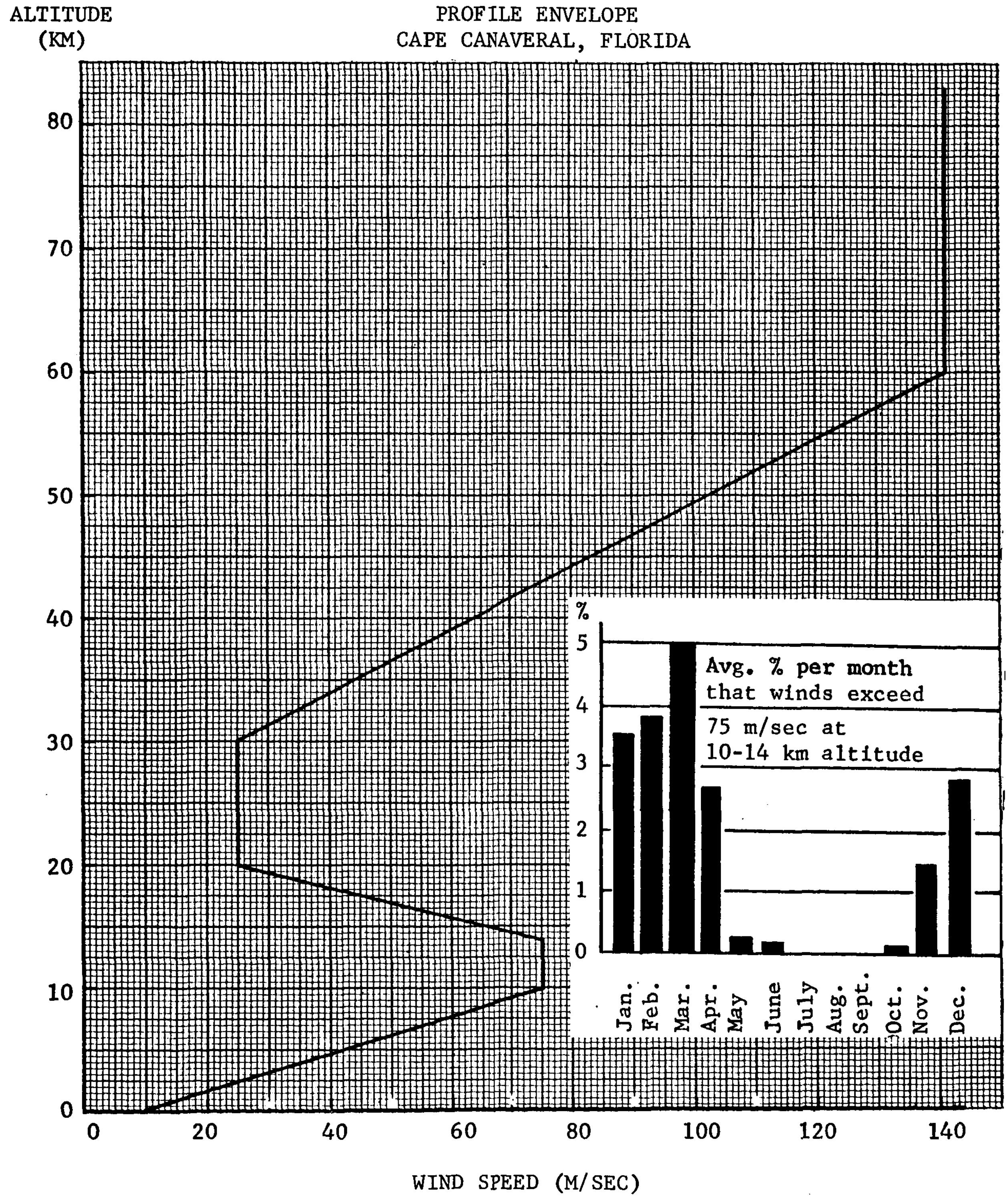


FIGURE 2.4
NINETY NINE PRECENT PROBABILITY OF OCCURRENCE WIND SPEED PROFILE ENVELOPE
CAPE CANAVERAL, FLORIDA

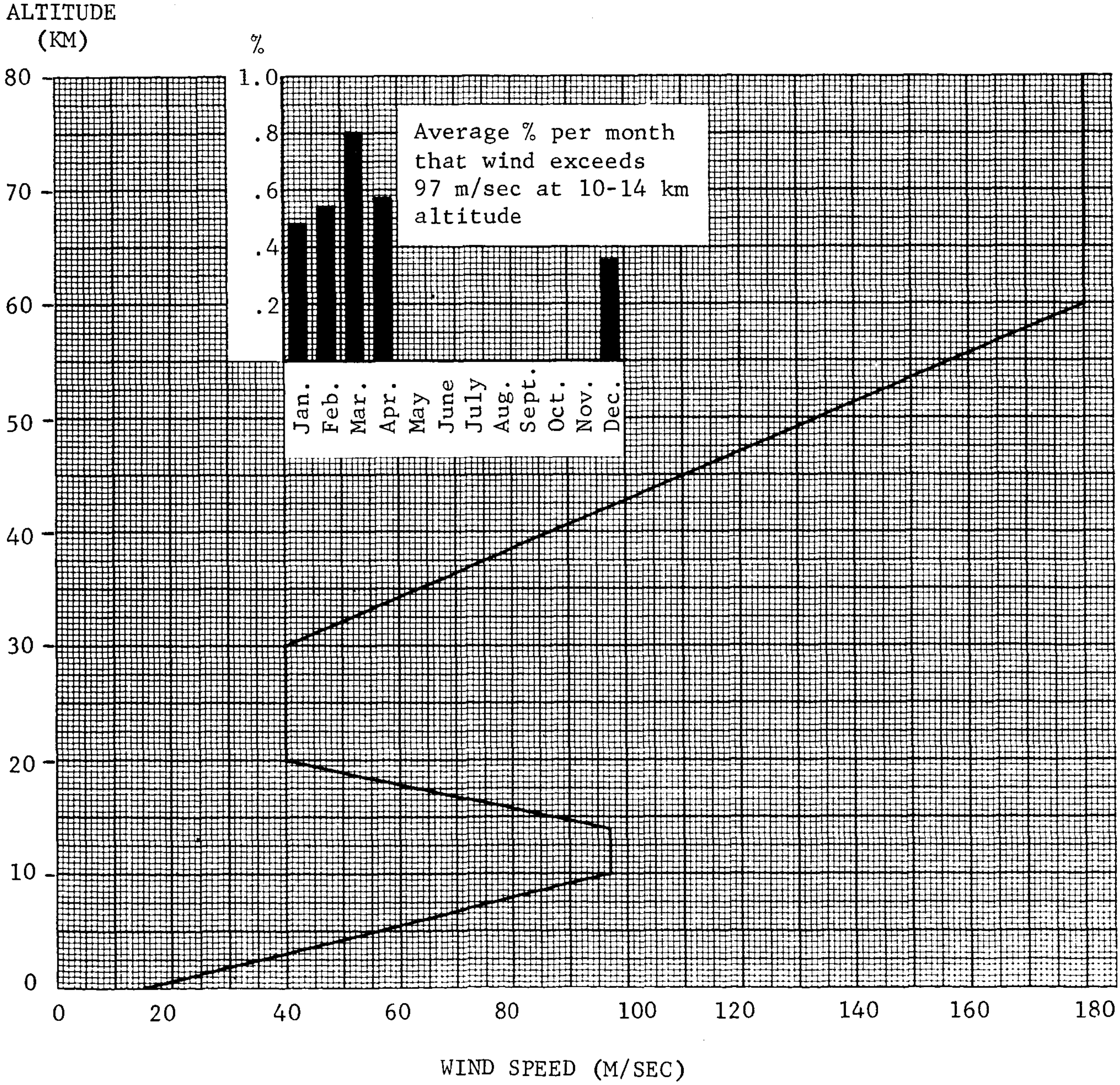


FIGURE 2.5
NINETY NINE PERCENT PROBABILITY OF OCCURRENCE
VERTICAL WIND SHEAR SPECTRUM AS FUNCTION OF
ALTITUDE AND SCALE-OF-DISTANCE FOR ASSOCIATION
WITH THE NINETY-FIVE PERCENT WIND SPEED PROFILE
ENVELOPE FOR CAPE CANAVERAL, FLORIDA

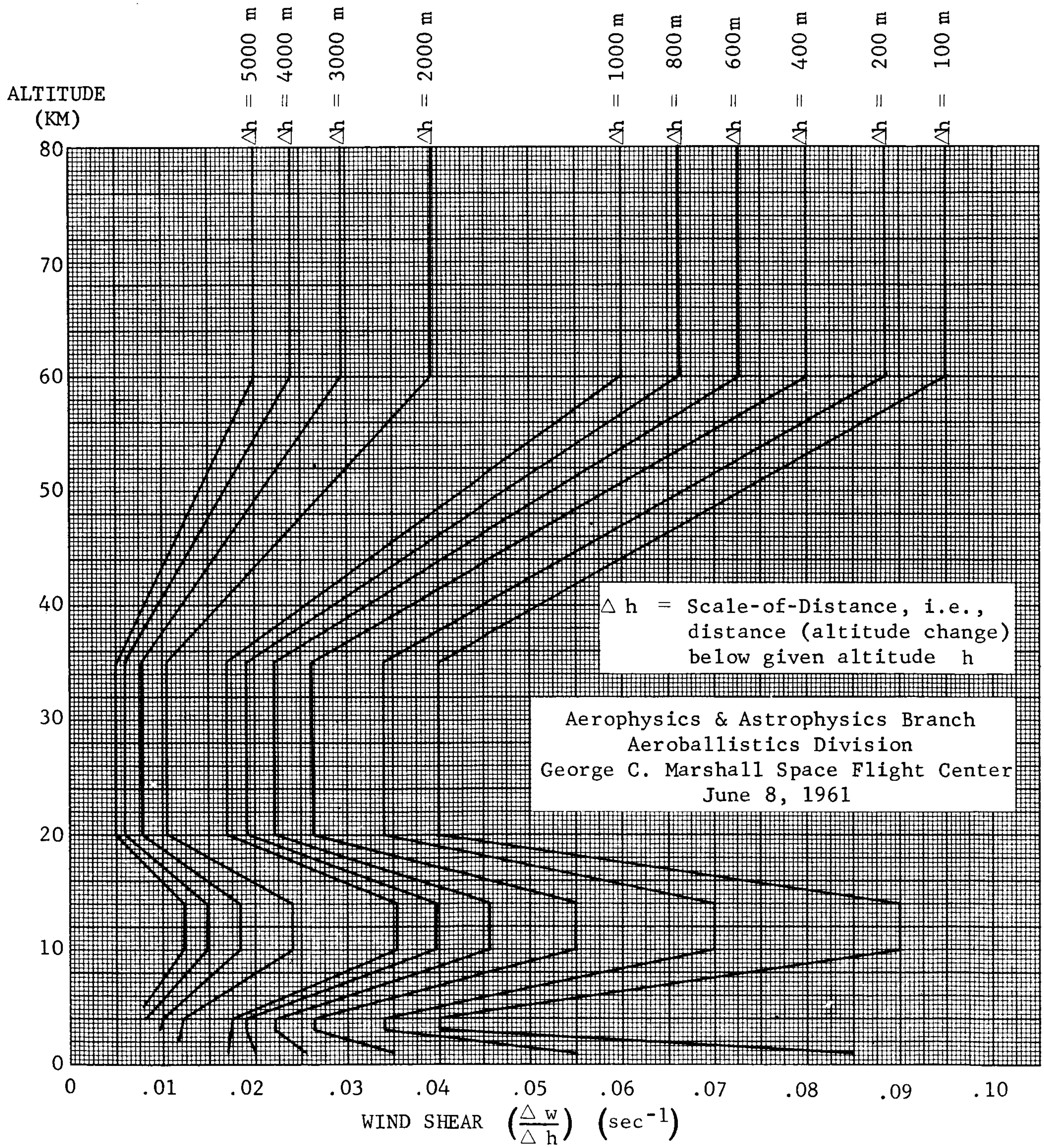
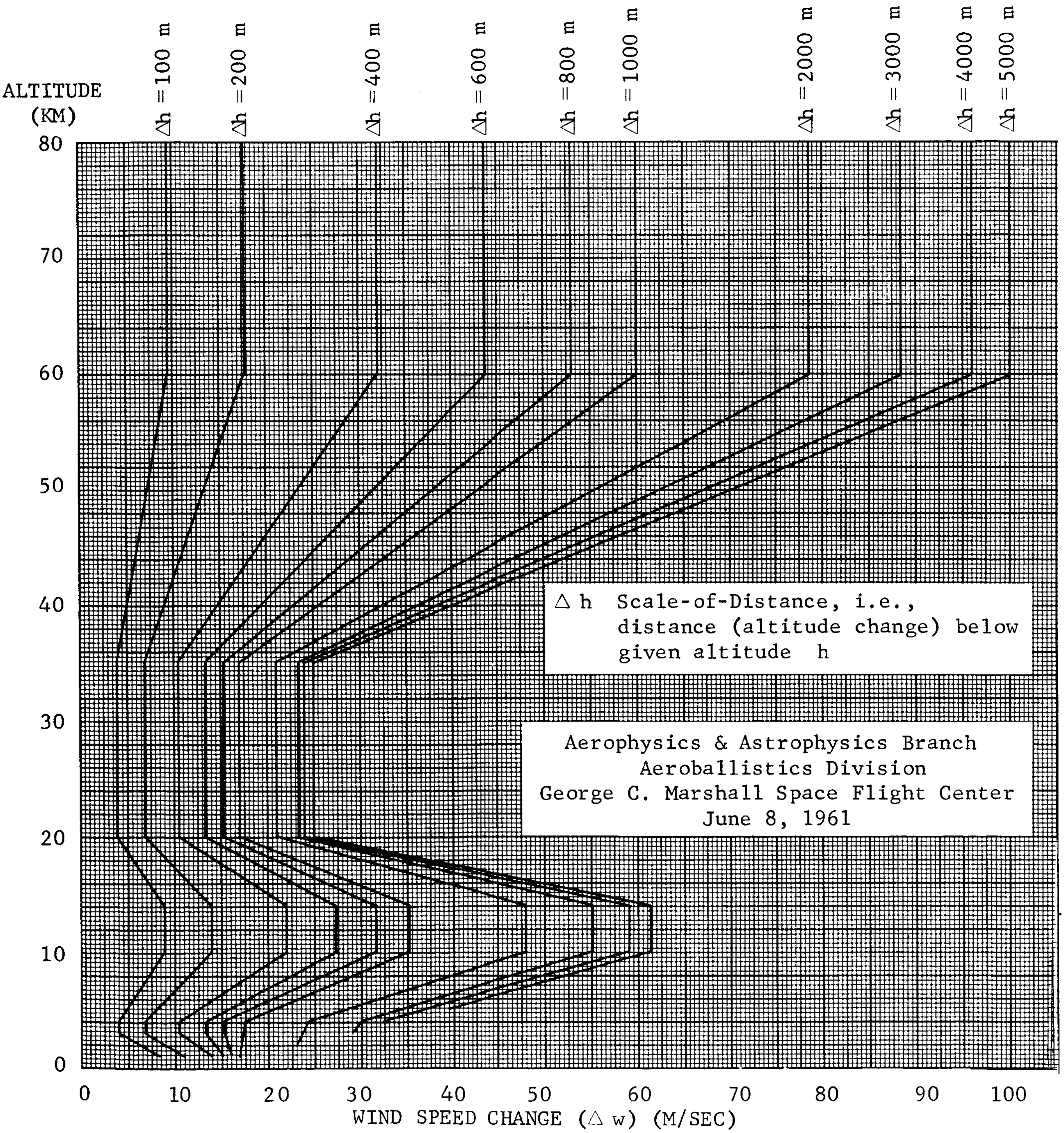


FIGURE 2.6
NINETY NINE PERCENT PROBABILITY OF OCCURRENCE
VERTICAL WIND SPEED CHANGE SPECTRUM AS FUNCTION
OF ALTITUDE AND SCALE-OF-DISTANCE ASSOCIATED
WITH THE NINETY-FIVE PERCENT WIND SPEED PROFILE
ENVELOPE



2.5 ABRASION

Particles carried by the wind will cause scratches, abrasion or erosion on exposed surfaces, remove paint, and pit transparent surfaces. This damage occurs whenever the hardness of the particles is equal to or greater than the exposed surface.

2.5.1 Sand and Dust. - Large sand and dust particles will only occur in the atmosphere during periods of dry weather and low humidities. Small particles below 0.002 mm in diameter are common at any time near or over land surfaces. Particles in the atmosphere over the sea will consist almost entirely of salt particles. Extreme values expected for sand and dust are as follows:

a. Particle Size

(1) Sand particles are between 0.01 and 1.0 mm in diameter. At least 90 percent of these particles are between 0.015 and 0.30 mm in diameter.

(2) Dust particles are between 0.0001 and 0.01 mm in diameter. At least 90 percent are between 0.0005 and 0.002 mm in diameter.

b. Hardness and Shape

More than 50 percent of the sand and dust particles have hardness of at least 7 MOHS scale of hardness (Ref. 12, p. 95). These particles are angular in shape.

c. Number of Particles and Distribution

(1) Sand - With 15 m/sec (33.6 mph) steady state wind speed and relative humidity under 30 percent, there would be 0.02 gram /cm^3 (1.25 lb/ft^3) suspended in the atmosphere. Under these conditions, 10 percent of the sand grains will be between 0.02 meter (.07 ft) and one meter (3.28 ft) above the ground, the remaining 90 percent below 0.02 meter (.07 ft).

(2) Dust - With 15 m/sec (33.6 mph) steady state wind speed and relative humidity under 30 percent, there would be 6 x 10^{-9} gram/cm^3. Distribution is uniform with height above the ground.

Since only small particles of dust (less than 0.002 mm in diameter) will be in the atmosphere above 400 meters (1312 ft), only surface environment sand and dust will be of importance in abrasion. During flight, the vehicle will be exposed to this environment for such a small time duration that no detrimental effects should result.

2.5.2 Snow and Hail - Snow and hail particles are sometimes hard enough to cause abrasion. Hardness, particle size, associated wind speed, and air temperature for the Huntsville, river transportation and New Orleans areas are as follows:

Snow particles with a hardness of 1-1/2 to 4 MOHS scale of hardness (Ref. 13) are 1 to 3 mm in diameter. Steady state wind speed is 15 m/sec (33.6 mph) and the air temperature is -18°C (0°F), except at New Orleans where the air temperature is -9°C (+16°F).

Hail particles with a hardness of 1-1/2 to 4 MOHS scale of hardness are greater than 3 mm in diameter. Steady state wind speed is 15 m/sec (33.6 mph) and the air temperature is +10°C (+50°F).

Snow and hail particles can cause more severe abrasion damage at higher altitudes than at the surface since the hardness of the particles increases with lower temperatures (Ref. 13). Approximate hardness of snow and hail particles with respect to temperature is as follows:

Temperature		Hardness
°C	°F	(MOHS, Scale of Hardness)
0	+32	2
-20	-4	3
-40	-40	4
-60	-76	5

2.6 HUMIDITY

2.6.1 Probable Humidity Extremes at Ground Level

High Humidity - The following paragraphs present the weight of water vapor per unit volume, associated temperatures and relative humidities.

a. Huntsville, river transportation and Pacific Missile Range Area:

A simulated twenty four (24) hour cycle of water vapor in the atmosphere with a 5 m/sec (11.2 mph) steady state wind shall be made as follows:

(1) Six (6) hours of 46°C (115°F) air temperature at 50 percent (absolute humidity of 35 grams/m^3 (15.3 grains/ft^3)).

(2) Six (6) hours of decreasing air temperature to 33°C (91°F) and increasing relative humidity to 100 percent.

(3) Eight (8) hours of decreasing air temperature to 30°C (86°F) with a release of 4 grams of water per cubic meter (1.7 grains/ft^3).

(4) Four (4) hours of increasing air temperature to 45°C (113°F) and decreasing relative humidity to 45 percent (see figure 2.7, p. 2-22).

b. New Orleans, Gulf transportation, Atlantic Missile Range and Panama Canal transportation areas.

A simulated twenty four (24) hour cycle of water vapor in the atmosphere with a 5 m/sec (11.2 mph) steady state wind shall be made as follows:

(1) Six (6) hours of 41°C (106°F) air temperature at 65 percent relative humidity (absolute humidity of 35 grams/m^3 (15.3 grains/ft^3)).

(2) Six (6) hours of decreasing air temperature to 33°C (91°F) and increasing relative humidity to 100 percent.

(3) Eight (8) hours of decreasing air temperature to 27°C (81°F) with a release of 10 grams of water per cubic meter (4.4 grains/ft^3).

2.6.1 Cont'd

(4) Four (4) hours of increasing air temperature to 41°C (106°F) and decreasing relative humidity to 50 percent (see figure 2.8, p. 2-23).

2.6.2 Probable Humidity at Altitude - Reference 17 contains the current acceptable information for median humidity values with respect to height. High humidity values should be taken as 100 percent relative humidity up to approximately 15 kilometers (49,200 ft.)

FIGURE 2.7
PROBABLE HIGH HUMIDITY EXTREMES
FOR HUNTSVILLE, RIVER TRANSPORTATION
AND PACIFIC MISSILE RANGE AREAS

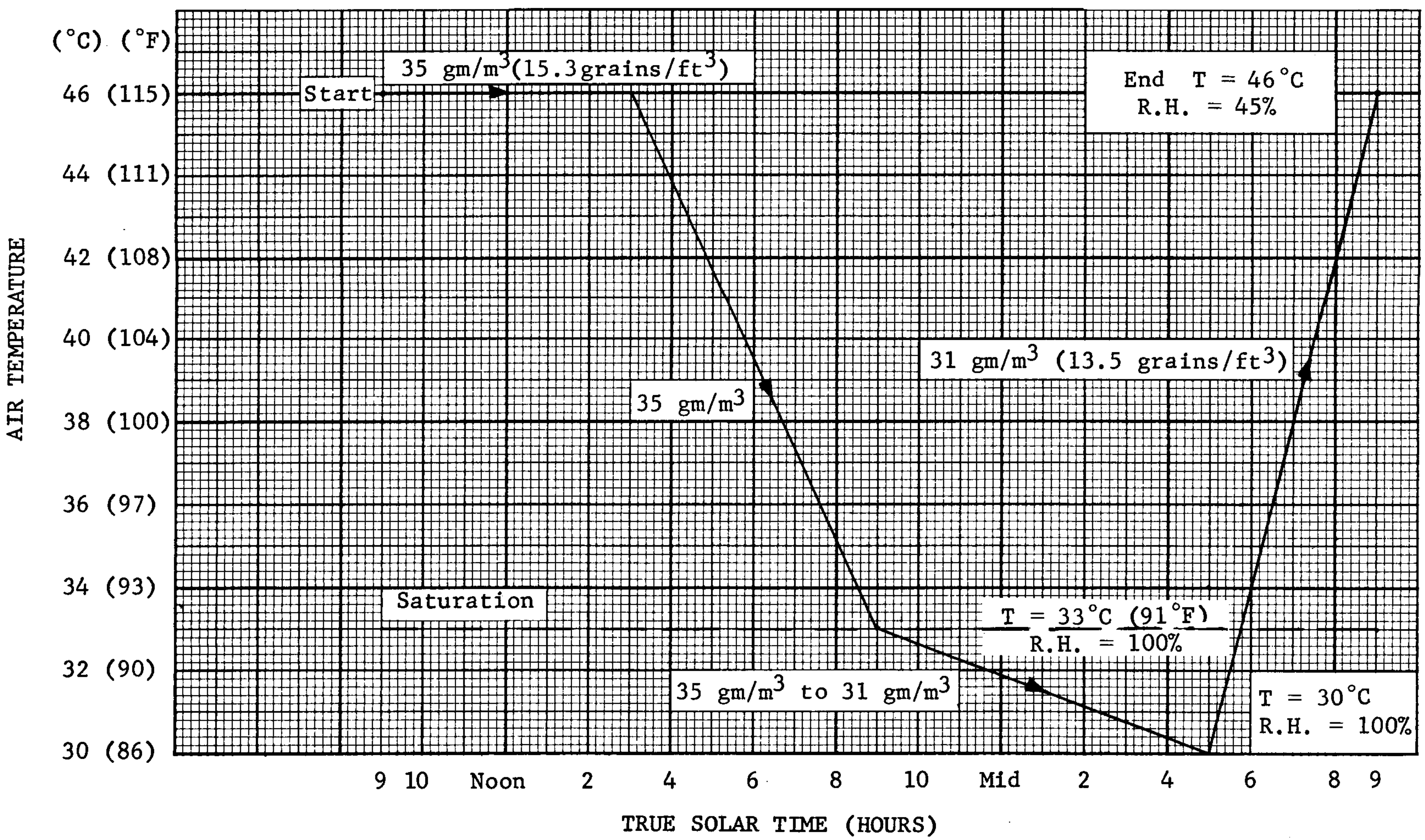
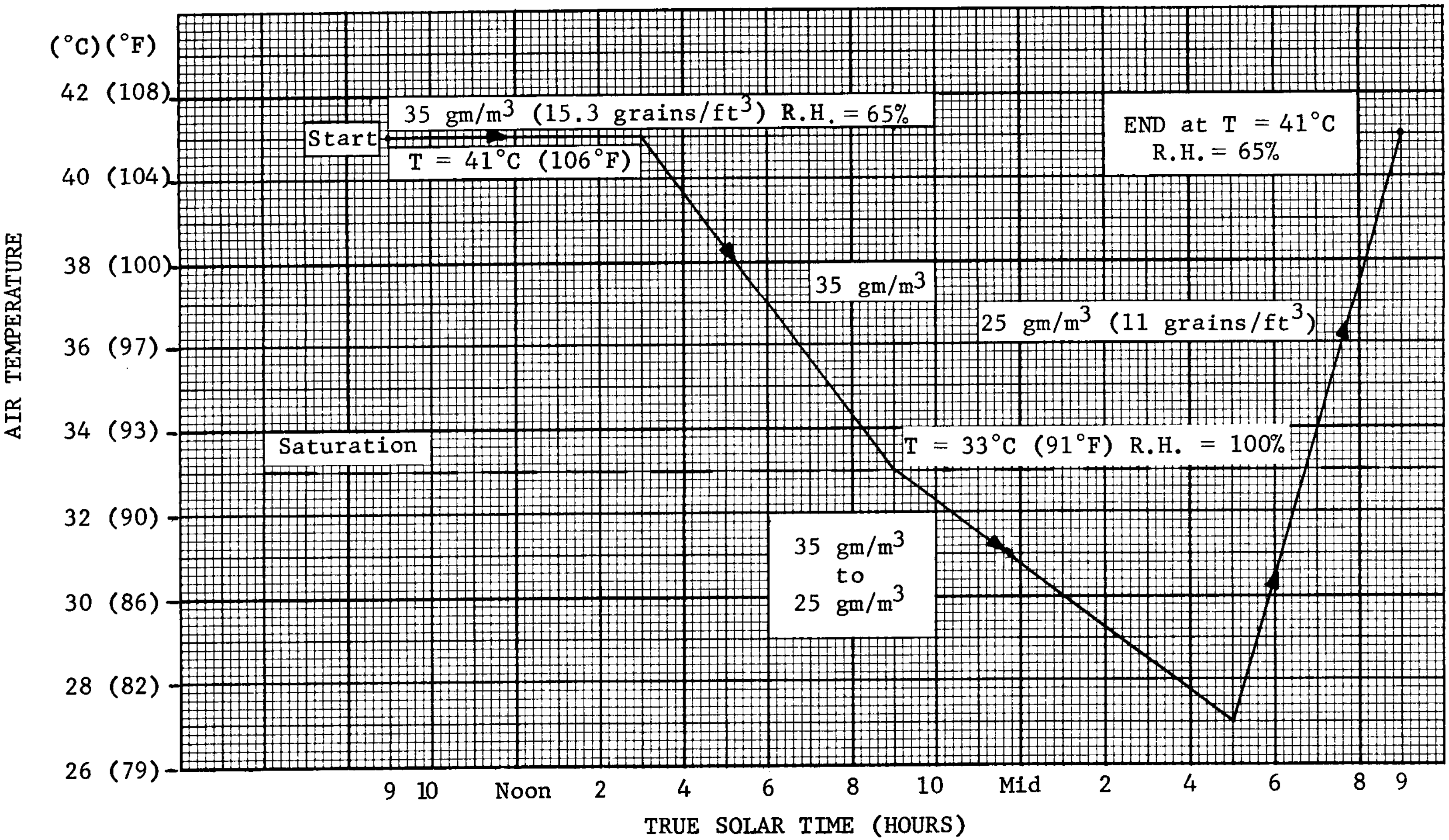


FIGURE 2.8
PROBABLE HIGH HUMIDITY EXTREMES
FOR NEW ORLEANS, GULF TRANSPORTATION,
ATLANTIC MISSILE RANGE AND
PANAMA CANAL TRANSPORTATION AREAS



2.7 PRECIPITATION

2.7.1 Probable Extreme Precipitation At Ground Level

Rain - The following paragraphs present information on rainfall intensities and the distribution of these intensities during a 24-hour period. An air temperature between 21°C (70°F) (night) and 32°C (90°F) (day) can be assumed. (Refs. 1, 6, 7, 8, 9, and 10)

a. Huntsville and Atlantic Missile Range

(1) Expected Extreme Rates

Time Period	Expected Values			
	Maximum Rate		Total Accumulation for Period	
	mm/hr	in/hr	mm	inches
1 min.	300	12	5	0.2
5 min.	150	6	12.5	0.5
1 hour	50	2	50	2
12 hours	15	0.6	180	7.1
24 hours	12.5	0.5	300	12

(2) Expected Extreme Distribution

Total Amount		Time	Rate	
mm	inches		mm/hr	in/hr
180	7.1	12 hours	15	0.6
12.5	0.5	5 minutes	150	6
5	0.2	1 minute	300	12
102.5*	4.0*	12 hours	8.5	0.34

*Peak wind speed 20 m/sec (44.7 mph) during this period.

2.7.1 Cont'd

b. River Transportation and New Orleans Areas

(1) Expected Extreme Rates

Time Period	Expected Values			
	Maximum Rate		Total Accumulation for Period	
	mm/hr	in/hr	mm	inches
1 min.	380	15	6.3	0.25
5 min.	190	7.5	16	0.6
1 hour	95	3.7	95	3.7
12 hours	20	0.8	240	9.4
24 hours	16	0.6	380	15

(2) Expected Extreme Distribution

Total Amount		Time	Rate	
mm	inches		mm/hr	in/hr
240	9.4	12 hours	20	0.8
16	0.6	5 minutes	190	7.5
6.3	0.25	1 minute	380	15
118*	4.60*	12 hours	9.8	0.39

*Peak wind speed 20 m/sec (44.7 mph) during this period.

c. Gulf Transportation Area

(1) Expected Extreme Rates

Time Period	Expected Values			
	Maximum Rate		Total Accumulation for Period	
	mm/hr	in/hr	mm	inches
1 min.	900	35.4	15	0.6
5 min.	450	18	38	1
1 hour	225	9	225	9
12 hours	45	1.8	540	21
24 hours	38	1.5	900	35.4

2.7.1 Cont'd

(2) Expected Extreme Distribution

Total Amount		Time	Rate	
mm	inches		mm/hr	in/hr
540	21	12 hours	45	1.8
38	1.5	5 minutes	450	18
15	0.6	1 minute	900	35.4
308*	12	12 hours	26	1.0

*Peak wind speed 20 m/sec (44.7 mph) during this period

d. <u>Panama Canal Transportation Area</u>

(1) Expected Extreme Rates

Length of Period	Expected Values			
	Maximum Rate		Total Accumulation for Period	
	mm/hr	in/hr	mm	inches
1 min.	1800	71	30	1.2
5 min.	900	35.4	75	3
1 hour	450	18	450	18
12 hours	90	3.5	1080	42.5
24 hours	75	3	1800	71

(2) Expected Extreme Distribution

Total Amount		Time	Rate	
mm	inches		mm/hr	in/hr
1080	42.5	12 hours	90	3.5
75	3	5 minutes	900	35.4
30	1.2	1 minute	1800	71
615*	24.2*	12 hours	51	2

*Peak wind speed 20 m/sec (44.7 mph) during this period

2.7.1 Cont'd

Snow - Snow will have the following environmental effects on equipment:

The accumulation of snow results in stresses proportional to the weight of snow accumulated. For flat horizontal surfaces, the weight is proportional to the amount of snow directly above the surface. For long narrow objects laying above a flat surface (that can accumulate snow), the stress is approximately equal to the weight of a wedge of snow with the sharp edge along the object and extending above the object in both directions at about 45^o to the vertical. The weight of new fallen snow varies between 2 kg/m^2 (1.04 psf.) and 0.5 kg/m^2 (0.26 psf.) per centimeter (inch) of depth. The weight of snow on the ground several days after falling will be between 3 kg/m^2 (1.56 psf.) and 6 kg/m^2 (3.12 psf.) per centimeter (inch) of depth.

Extreme snow loads are as follows:

(1) Huntsville and River Transportation areas.

For horizontal surfaces 2.5 kg/m^2 (0.51 psf.) per 24 hour period to a maximum of 7 kg/m^2 (1.43 psf.) in three consecutive 24-hour periods, if snow is not cleared during storm.

(2) New Orleans Area

For horizontal surfaces, 1 kg/m^2 (0.2 psf.) per 24 hour period.

Particle size and associated wind and air temperatures are as follows:

Huntsville, River Transportation and New Orleans Area:

Snow particles 1 to 3 mm diameter; wind, 20 m/sec (44.7 mph), temperature -18^oC (0^oF), except at New Orleans where the temperature is $-9°C$ ($16°F$).

Hail - Hail is formed in extremely well developed thunderstorms during warm weather and rarely occurs in winter months or when the air temperature is below 0^oC (32^oF). Hail stones larger than 12.5 mm in diameter frequently occur, while stones 50 mm in diameter can be expected somewhere in the United States every year.

Hail has a much higher density than snow and has a weight of about 2.4 kg/m^2 (1.25 psf.) per cm (inch) of depth. Extreme load from hail is 4 kg/m^2 (0.82 psf.) on a horizontal surface during one 24-hour period for all geographical localities north of 20^o N latitude.

The actual designation of areas where hail storms with specific sizes of hail will occur is difficult. As a guide to the engineer, the following information should be useful. The need for protection of space vehicles is greatest during May through September, and while

2.7.1 Cont'd

the vehicles are being transported from Huntsville to New Orleans or Cape Canaveral areas.

For geographical localities north of 25° north latitude, hail stones of certain sizes have the following expectancy of occurrence during a one year period:

Hail Stone Diameter mm	Percent Time of Expected Occurrence (Annual)
12.5 or larger	0.1
25 or larger	0.04
50 or larger	0.02
75 or larger	0.006

2.7.2 <u>Probable Extreme Precipitation at Altitude</u>

<u>Rain</u> - The distribution of maximum rainfall rates with altitude compared to the surface rates is as follows (Ref. 6):

Altitude		Surface Rate (percent of)
km	ft	
Ground Level	-	100
1	3,280	90
2	6,560	75
3	9,840	57
4	13,120	34
5	16,400	15
6	19,680	7
7	22,960	2
8	26,240	1
9	29,520	0.1
10 and over	32,800 and over	0

2.7.2 Cont'd

Icing can be expected to occur in precipitation type clouds when the temperature is +2°C (+35.6°F) and lower. For the areas considered, these conditions usually occur between 4 km (13,120 ft) and 10 km (32,800 ft) altitude.

<u>Hail</u> - The probability of hail with altitude increases from the surface to 5.0 km (16,400 ft) and then decreases rapidly with increasing height. Data from Florida thunderstorms giving the number of times hail was encountered at various altitudes during aircraft flights through thunderstorms (Ref. 23, p. 48) is as follows:

Altitude		Occurrence of Hail (percent of flights)
km	feet	
2	6,560	0
3.5	11,480	3
5	16,400	10
6	19,680	4
8	26,240	3

TABLE 2.1

SUMMARY OF HYDROMETEOR CHARACTERISTICS

Type of Hydrometeor	Altitude (km)	Drop Diameter (microns)		Concentration per Unit Volume (cm^3)		Liquid Water Content Per Unit Volume (gm per m^3)		Ambient Temperature (°C)
	Range	Range	Rep.[1]	Range	Rep.	Range	Rep.	Range ≈
Layer Clouds	sfc-1.5	1-40	11	10-10,000	500	0.1-1	0.2	+30 to -15
Layer Clouds	2.5-7.5	1-50	12	20-1000	100	0.1-1	0.2	+20 to -25
Layer Clouds (ice crystals)	7.5-15.0	10-10,000	100	0.1-10	0.2	0.01-0.1	0.02	-10 to -55
Convective Clouds Fair Weather Cumulus	0.5-8.0	1-75	12	10-10,000	300	0.1-1	0.5	+20 to -30
Cumulus Congestus	0.5-13.0	1-200	25	10-10,000	150	1-10	4.0	+20 to -55
Continuous Type Rain	sfc-6.0	500-3000	1000	50-3000[2]	500[2]	0.05-0.7	0.1	+30 to -15
Shower Type Rain	sfc-13.0	500-7000	2000	10-3000[2]	500[2]	0.1-30	1.0	+30 to -55
Coalescence (warm) Rain	sfc-5.0	100-1000	500	500-50,000[2]	3000[2]	0.05-0.1	0.1	+30 to 0
Hail	sfc-13.0	0.01-13 cm	0.8 cm	0.5-1000[2]	50[2]	0.1-0.9[3]	0.8[3]	+15 to -55
Ice and Snow Crystals	sfc-13.0	100-20,000	5000	1-1000[2]	100[2]	0.001-0.7[4]	0.7[4]	+5 to -55

1. Rep: Representative value most frequently encountered
2. Per m^3
3. Density of particles (gm per cm^3)
4. Mass of crystals (milligram)

2.8 CORROSION AND CONTAMINATION

2.8.1 Salt Spray - Wind blowing over sea waves drives microscopic particles and droplets of salt some distance before they settle out on the surrounding territory. This salt laden atmosphere is generally concentrated at distances less than five to ten miles inland. However, this condition varies considerably with climate, wind velocity and direction, and has been observed at times as much as 161 km (100 miles) inland.

2.8.2 Fungi and Bacteria - Fungi, including molds, and bacteria have the highest rate of growth at temperatures between 20°C (68°F) and 38°C (100°F) and relative humidities between 75 and 95 percent (Ref. 16). Damage from fungi and bacteria can occur to organic materials, plastics, glass, paints and metals. Therefore, proper fungus proofing measures are required at the following localities:

a. River Transportation Area

b. New Orleans Area

c. Gulf Transportation Area

d. Panama Canal Transportation Area

e. Atlantic Missile Range Area, Cape Canaveral, Florida

2.9 ATMOSPHERIC ELECTRICITY

2.9.1 Thunderstorm Electricity - Thunderstorm electricity can cause damage to space vehicle not properly protected in either of three ways (a) by direct lightning strike, (b) by induced current from a lightning strike through a nearby object or, (c) by a charge induced by nearby charged clouds. An average lightning stroke reaches a peak current strength of about 10,000 amperes, while some exceed 100,000 amperes, (Ref. 14 and 15). It is not feasible to prevent lightning from striking a certain area. Therefore an object must be protected by diverting the lightning through regions of the object where little or no damage will occur. The following gives the mean number of days per year of thunderstorm occurrence:

Location	Thunderstorm Occurrence (mean no. of days per yr)
Huntsville Area	60
River Transportation Area	80
New Orleans Area	80
Gulf Transportation Area	90
Atlantic Missile Range Area, Cape Canaveral, Fla.	90
Panama Canal Transportation Area	100
Pacific Missile Range Area, Pt. Mugu, Calif.	5

2.9.2 Static Electricity - Static electricity can result in a charge of electricity by motion of the object through air containing dust or snow particles. Such a charge will build up until a potential is reached sufficiently high to bridge an air gap to the ground. This type of charge may be prevented by grounding all metallic parts. Such a discharge will occur more frequently during periods of low humidities and can be expected to occur at all locations concerned.

2.10 ATMOSPHERIC DENSITY

The density variation of the atmosphere, at the surface, is so small that it has no environmental effect on preflight operations.

The density of the atmosphere changes rapidly with height. The density at 7 kilometers(22,960 ft) is only one half the density at the surface.

References 17, 18 and 21 summarize the current acceptable information on average, maximum, and minimum densities with respect to height.

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SECTION III

VEHICLE INDUCED ENVIRONMENTS

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SECTION III
VEHICLE INDUCED ENVIRONMENTS

3.1 INTRODUCTION

This section consists of the detailed breakdown of the induced environmental criteria. For the manufacturing, storage and transportation phases of the Saturn vehicle, the applicable environmental data is presented for each individual stage and is representative of the environment the entire stage will experience.

For the test, launch and flight phases, the applicable data is presented on a more detailed basis. Each stage has been assigned an arbitrary zone breakdown. Detailed environmental data for these specific zones is listed.

Applicable military specifications that can be used as a guide in the design of vehicle components to minimize the problems of electrical interference, explosive conditions and corrosion are referenced in paragraphs given below. Because of its general nature, this information is applicable to all phases of vehicle life listed in this section.

3.1.1 Electrical Interference - Interference is any electrical or electromagnetic disturbance, phenomenon, signal or emission, manmade or natural, which causes or can cause undesired response, malfunctioning or degradation of performance of electrical and electronic equipment.

References:

MIL-E-6051C

Electrical - Electronic System Compatibility and Interference Control Requirements for Aeronautical Weapon Systems, Associated Subsystems and Aircraft

MIL-I-26600 (USAF)

Interference Control Requirements, Aeronautical Equipment

MIL-I-6181D

Interference Control Requirements, Aircraft Equipment

3.1.2 Explosive Conditions - When the design or application of electrical equipment calls for the installation of said equipment in locations where explosive fumes may be generated, all details of the design shall minimize the possibility of explosion. This can be accomplished by providing electrical bonding, static discharges or explosion - proof housings as necessary for contact points, switches and rotating electrical equipment to prevent arcing or sparks from any cause.

References:

U. S. A. F. Specification Bulletin #106A

General Environmental Criteria for Guided Missile Weapon Systems

Marshall Drawing 10M01071

Procedure for Environmental Protection When Using Electrical Equipment Within the Areas of Saturn Complexes Where Hazardous Areas Exist

3.1.3 Corrosion - Corrosion is the most serious result of exposure to high humidity conditions. Unprotected metals such as nuts, bolts, screws, etc. are most susceptible to corrosion. Galvanic corrosion resulting from contact of dissimilar materials takes place at a rapid rate in the presence of moisture. To minimize this problem, consideration should be given in the design of vehicle components to provide protective coatings or minimize the use of dissimilar contacting materials. Reference to the military specifications listed below should be helpful in eliminating possible sources of corrosion.

References:

MFSC-STD-181
MIL-STD-171
MIL-STD-186

3.1.4 Vibration - The failure mechanism whether structural failure or equipment, may be caused by the vehicle vibratory responses. The responses are divided into two principal types.

a. Transient Vibrations

Transient vibrations are present only for short periods of time. They are relatively high in magnitude. These severe vibrations normally occur during stage ignition, vehicle liftoff, cutoff, and separation. In general, the transient vibrations do not exceed eight (8) seconds.

3.1.4 Cont'd

b. Steady State Vibration

Steady state vibrations are present for relatively long periods of time. In general, they are characterized by constant vibration magnitudes. These levels occur during the test and flight phases and are present for the major portion of engine burning time.

References:

M-S&M-SD-311 dated Sept. 13, 1961. Anticipated Vibration and Acoustic Levels for the Saturn C-1 Flight Vehicle

M-S&M-SD-343 dated October. 9, 1961 Saturn C-1 Vehicle Shock, Vibration and Acoustic Environmental Criteria.

3.1.5 Acoustics - The acoustic environment is of primary importance because of its adverse effect on structures and components. The local vibrational energy developed in the vehicle structures is absorbed primarily from the acoustic environment. This environment is derived from the rocket engine exhaust gases and the turbulent airflow over the exterior vehicle surfaces during atmospheric flight.

The structures and components act as mechanical filters because of their frequency dependent characteristics. Hence it is necessary to define the frequency characteristics of the acoustic field as well as the magnitude. The characteristics were investigated for a variety of vehicle conditions e.g., static firing tests, pre-liftoff on pad conditions and inflight conditions.

3.2 S-I STAGE

	Manufacture	Storage	Transportation
Shock			
Vibration			
Acceleration			
Acoustics			
Temperature			

No data available for these phases at this time.

3.3 S-IV STAGE

	Manufacture	Storage	Transportation
Shock			
Vibration			
Acceleration			
Acoustics			
Temperature			

No data available for these phases at this time.

3.4 INSTRUMENT UNIT

	Manufacture	Storage	Transportation
Shock			
Vibration			
Acceleration			
Acoustics			
Temperature			

No data available for these phases at this time.

3.5 ZONE 1

3.5.1 TEST PHASE

Shock	150 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-43 cps at 0.45 inch D.A. 43-84 cps at 32 g peak 84-119 cps at 0.09 inch D.A. 119-2000 cps at 65 g peak	16-43 cps at 0.23 inch D.A. 43-84 cps at 16 g peak 84-119 cps at 0.05 inch D.A. 119-2000 cps at 32.5 g peak
Acoustics	See Figures 3.1 and 3.2	
Compartment Temperature	Area below heat shield: no data available Area between heat shield and firewall + 40°F to + 75°F.	

ZONE 1

3.5.2 LAUNCH PHASE

Shock	150 g for 8 milliseconds - half sine pulse
Vibration	TRANSIENT 16-43 cps at 0.45 inch D.A. 43-84 cps at 32 g peak 84-119 cps at 0.09 inch D.A. 119-2000 cps at 65 g peak
Acoustics	See figures 3.1 and 3.2
Skin Temperature	No data available
Compartment Temperature	Area below heat shield: 90°F maximum Area between heat shield and firewall +40°F to + 75°F.

ZONE 1

3.5.3 FLIGHT PHASE

Shock	150 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-43 cps at 0.45 inch D.A. 43-84 cps at 32 g peak 84-119 cps at 0.09 inch D.A. 119-2000 cps at 65 g peak	16-43 cps at 0.23 inch D.A. 43-84 cps at 16 g peak 84-119 cps at 0.05 inch D.A. 119-2000 cps at 32.5 g peak
Acceleration	Maximum lift-off acceleration 1.39 g Maximum longitudinal acceleration 6.59 g	
Acoustics	See figures 3.1 and 3.2	
Skin Temperature	Outboard engine shroud (0.04 SS plus 0.4 in. X-258): + 770°F maximum. Cylindrical surface near fin root: + 470°F maximum. Cylindrical surface not influenced by fins: + 280°F maximum.	
Compartment Temperature	Area below heat shield: no data available. Area between heat shield and firewall: + 40°F to + 200°F.	

3.6 ZONE 2

3.6.1 TEST PHASE

Shock	100 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-28 cps at 0.35 inch D.A. 28-100 cps at 15 g peak 100-189 cps at 0.029 inch D.A. 189-2000 cps at 52 g peak	16-28 cps at 0.18 inch D.A. 28-100 cps at 7.5 g peak 100-189 cps at 0.015 inch D.A. 189-2000 cps at 26 g peak
Acoustics	See Figure 3.2 and 3.3	
Compartment Temperature	0°F ± 10°F center Lox barrel 20°F ± 10°F outside of center barrel	

ZONE 2

3.6.2 LAUNCH PHASE

Shock	100 g for 8 milliseconds - half sine pulse
Vibration	TRANSIENT 16-28 cps at 0.35 inch D.A. 28-100 cps at 15 g peak 100-189 cps at 0.029 inch D.A. 189-2000 cps at 52 g peak
Acoustics	See figures 3.2 and 3.3
Skin Temperature	+ 80°F maximum
Compartment Temperature	0°F ± 10°F center Lox barrel + 20°F ± 10°F outside of center barrel

ZONE 2

3.6.3 FLIGHT PHASE

Shock	100 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-28 cps at 0.35 inch D.A. 28-100 cps at 15 g peak 100-189 cps at 0.029 inch D.A. 189-2000 cps at 52 g peak	16-28 cps at 0.18 inch D.A. 28-100 cps at 7.5 g peak 100-189 cps at 0.015 inch D.A. 189-2000 cps at 26 g peak
Acceleration	Maximum lift-off acceleration 1.39 g Maximum longitudinal acceleration 6.59 g	
Acoustics	See figures 3.2 and 3.3	
Skin Temperature	No data available	
Compartment Temperature	+ 40°F to + 200°F outside of center Lox barrel 0°F ± 10°F in center Lox barrel	

3.7 ZONE 3

3.7.1 TEST PHASE

<table>
<tr><td>Shock</td><td colspan="3">100 g for 8 milliseconds - half sine pulse</td></tr>
<tr><td rowspan="2">Vibration</td><td colspan="2">TRANSIENT</td><td>STEADY STATE</td></tr>
<tr><td colspan="2">16-28 cps at 0.35 inch D.A.
28-100 cps at 15 g peak
100-189 cps at 0.029 inch D.A.
189-2000 cps at 52 g peak</td><td>16-28 cps at 0.18 inch D.A.
28-100 cps at 7.5 g peak
100-189 cps at 0.015 inch D.A.
189-2000 cps at 26 g peak</td></tr>
<tr><td>Acoustics</td><td colspan="3">See Figures 3.3 and 3.4</td></tr>
<tr><td rowspan="3">Compartment Temperature</td><td>70 inch Lox Tank</td><td>Center Lox Tank</td><td>70 inch Fuel Tank</td></tr>
<tr><td>- 80°F ± 30°F</td><td>0°F ± 10°F</td><td>+ 20°F ± 10°F</td></tr>
<tr><td colspan="3">Temperature between tank areas + 40°F ± 20°F</td></tr>
</table>

ZONE 3

3.7.2 LAUNCH PHASE

<table>
<tr><td>Shock</td><td colspan="3">100 g for 8 milliseconds - half sine pulse</td></tr>
<tr><td>Vibration</td><td colspan="3">TRANSIENT
16-28 cps at 0.35 inch D.A.
28-100 cps at 15 g peak
100-189 cps at 0.029 inch D.A.
189-2000 cps at 52 g peak</td></tr>
<tr><td>Acoustics</td><td colspan="3">See figures 3.3 and 3.4</td></tr>
<tr><td>Skin Temperature</td><td colspan="3">No data available</td></tr>
<tr><td rowspan="3">Compartment Temperature</td><td>70-inch Lox Tank</td><td>105-inch Lox Tank</td><td>70-inch Fuel Tank</td></tr>
<tr><td>$-80^{\circ}F \pm 30^{\circ}F$</td><td>$0^{\circ}F \pm 10^{\circ}F$</td><td>$+20^{\circ}F \pm 10^{\circ}F$</td></tr>
<tr><td colspan="3">Temperature between tank areas $+40^{\circ}F \pm 20^{\circ}F$</td></tr>
</table>

ZONE 3

3.7.3 FLIGHT PHASE

Shock	100 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-28 cps at 0.35 inch D.A. 28-100 cps at 15 g peak 100-189 cps at 0.029 inch D.A. 189-2000 cps at 52 g peak	16-28 cps at 0.18 inch D.A. 28-100 cps at 7.5 g peak 100-189 cps at 0.015 inch D.A. 189-2000 cps at 26 g peak
Acceleration	Maximum lift-off acceleration 1.39 g Maximum longitudinal acceleration 6.59 g	
Acoustics	See figures 3.3 and 3.4	
Skin Temperature	30° fairing + 230°F maximum. (0.040" al. covered with 0.03" Thermoloy) Bottom propellant tank skirts + 97°F maximum.	

Compartment Temperature	70-inch Lox Tanks	105-inch Lox Tank	70-inch Fuel Tanks
	-110°F to + 130°F	0°F ± 10°F	+ 10°F to + 160°F

3.8 ZONE 4

3.8.1 TEST PHASE

Shock	150 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-43 cps at 0.45 inch D.A. 43-84 cps at 32 g peak 84-119 cps at 0.09 inch D.A. 119-2000 cps at 65 g peak	16-43 cps at 0.23 inch D.A. 43-84 cps at 16 g peak 84-119 cps at 0.05 inch D.A. 119-2000 cps at 32.5 g peak
Acoustics	See Figures 3.2, 3.3 and 3.4	
Compartment Temperature	Not applicable	

ZONE 4 3.8.2 LAUNCH PHASE	
Shock	150 g for 8 milliseconds - half sine pulse
Vibration	TRANSIENT 16-43 cps at 0.45 inch D.A. 43-84 cps at 32 g peak 84-119 cps at 0.09 inch D.A. 119-2000 cps at 65 g peak
Acoustics	See figures 3.2, 3.3 and 3.4
Skin Temperature	No data available
Compartment Temperature	Not applicable

ZONE 4

3.8.3 FLIGHT PHASE

Shock	150 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-43 cps at 0.45 inch D.A. 43-84 cps at 32 g peak 84-119 cps at 0.09 inch D.A. 119-2000 cps at 65 g peak	16-43 cps at 0.23 inch D.A. 43-84 cps at 16 g peak 84-119 cps at 0.05 inch D.A. 119-2000 cps at 32.5 g peak
Acceleration	Maximum lift-off acceleration 1.39 g Maximum longitudinal acceleration 6.59 g	
Acoustics	See figures 3.2, 3.3 and 3.4	
Skin Temperature	Leading edge of fin surface (uninsulated solid steel) + 1890°F maximum. Aluminum skin under 0.04 inch Thermoloy + 445°F maximum.	
Compartment Temperature	Not applicable	

3.9 ZONE 5

3.9.1 TEST PHASE

Shock	65 g for 8 milliseconds - half sine pulse		
Vibration	TRANSIENT	STEADY STATE	
	16-35 cps at 0.35 inch D.A. 35-2000 cps at 22 g peak	16-35 cps at 0.18 inch D.A. 35-2000 cps at 11 g peak	
Acoustics	See Figures 3.4, 3.5, 3.6, 3.7, and 3.8		
Compartment Temperature	Lox Tanks (internal)	Fuel Tanks (internal)	Area Between Propellant Tanks
	-297°F to -285°F NOTE: GOX Enters @ + 250°F	+35°F to +90°F	+40°F to ± 20°F

ZONE 5

3.9.2 LAUNCH PHASE

<table>
<tr><td>Shock</td><td colspan="3">65 g for 8 milliseconds - half sine pulse</td></tr>
<tr><td>Vibration</td><td colspan="3">TRANSIENT

16-35 cps at 0.35 inch D.A.
35-2000 cps at 22 g peak</td></tr>
<tr><td>Acoustics</td><td colspan="3">See figures 3.4, 3.5, 3.6, 3.7, and 3.8</td></tr>
<tr><td rowspan="2">Skin Temperature</td><td>Lox Tank</td><td colspan="2">Fuel Tank</td></tr>
<tr><td>- 80°F to - 297°F</td><td colspan="2">+ 35°F to + 90°F</td></tr>
<tr><td rowspan="3">Compartment Temperature</td><td>70-inch Lox Tanks (internal)</td><td>105-inch Lox Tank (internal)</td><td>70-inch Fuel Tanks (internal)</td></tr>
<tr><td>- 285°F to - 297°F</td><td>- 285°F to - 297°F</td><td>+ 35°F to + 90°F</td></tr>
<tr><td colspan="3">Temperature between tank areas + 40°F ± 20°F</td></tr>
</table>

ZONE 5

3.9.3 FLIGHT PHASE

Shock	65 g for 8 milliseconds - half sine pulse		
Vibration	TRANSIENT	STEADY STATE	
	16-35 cps at 0.35 inch D.A. 35-2000 cps at 22 g peak	16-35 cps at 0.18 inch D.A. 35-2000 cps at 11 g peak	
Acceleration	Maximum lift-off acceleration 1.39 g Maximum longitudinal acceleration 6.59 g		
Acoustics	See figures 3.4, 3.5, 3.6, 3.7, and 3.8		
Skin Temperature	Top of lox tank + 155°F maximum Top of fuel tank + 330°F maximum Hydrogen vent pipe + 300°F maximum Hydrogen vent pipe surface adjacent to rings and retainers + 430°F		
Compartment Temperature	70-inch Lox Tanks (internal)	105-inch Lox Tank (internal)	70-inch Fuel Tanks (internal)
	-297°F to - 285°F	-297°F to - 285°F	+ 35°F to + 100°F

3.10 ZONE 6

3.10.1 TEST PHASE

Shock	65 g for 8 milliseconds - half sine pulse			
Vibration	TRANSIENT		STEADY STATE	
	16-35 cps at 0.35 inch D.A. 35-2000 cps at 22 g peak		16-35 cps at 0.18 inch D.A. 35-2000 cps at 11 g peak	
Acoustics	See Figure 3.8			
Compartment Temperature	Above 70" Lox Tanks	Above 105" Lox Tank	Above Fuel Tanks	
			*F-1 & F-2	F-3 & F-4
	-10°F to +60°F	- 10°F to + 60°F	+55 °F to +65°F	+20°F to +80°F

* The instrument units are contained in fuel tanks 1 and 2.

ZONE 6

3.10.2 LAUNCH PHASE

Shock	65 g for 8 milliseconds - half sine pulse			
Vibration	TRANSIENT 16-35 cps at 0.35 inch D.A. 35-2000 cps at 22 g peak			
Acoustics	See figure 3.8			
Skin Temperature	No data available			
Compartment Temperature	Above 70-inch Lox Tank	Above 105-inch Lox Tank	Above 70-inch Fuel Tanks	
			*F-1 & 2	F-3 & 4
	- 10°F to + 60°F	- 10°F to + 60°F	+ 55°F to + 65°F	+ 20°F to + 80°F

*The instrument units are contained in fuel tanks 1 and 2.

ZONE 6

3.10.3 FLIGHT PHASE

<table>
<tr><td>Shock</td><td colspan="4">65 g for 8 milliseconds - half sine pulse</td></tr>
<tr><td rowspan="2">Vibration</td><td>TRANSIENT</td><td colspan="3">STEADY STATE</td></tr>
<tr><td>16-35 cps at 0.35 inch D.A.
35-2000 cps at 22 g peak</td><td colspan="3">16-35 cps at 0.18 inch D.A.
35-2000 cps at 11 g peak</td></tr>
<tr><td>Acceleration</td><td colspan="4">Maximum lift-off acceleration 1.39 g
Maximum longitudinal acceleration 6.59 g</td></tr>
<tr><td>Acoustics</td><td colspan="4">See figure 3.8</td></tr>
<tr><td>Skin Temperature</td><td colspan="4">Top skirt of Lox tank + 110°F maximum
Top skirt of fueltank + 230°F maximum</td></tr>
<tr><td rowspan="3">Compartment Temperature</td><td rowspan="2">Above 70-inch Lox Tank</td><td rowspan="2">Above 105-inch Lox Tank</td><td colspan="2">Above 70-inch Fuel Tank</td></tr>
<tr><td>F-1 & 2</td><td>F-3 & 4</td></tr>
<tr><td>-10°F to + 100°F</td><td>-10°F to + 60°F</td><td>Max +137°F</td><td>+ 20°F to +250°F</td></tr>
</table>

3.11 ZONE 7

3.11.1 TEST PHASE

Shock	65 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-35 cps at 0.35 inch D.A. 35-2000 cps at 22 g peak	16-35 cps at 0.18 inch D.A. 35-2000 cps at 11 g peak
Acoustics	See figures 3.8 and 3.9	
Compartment Temperature	No data available	

ZONE 7

3.11.2 LAUNCH PHASE

Shock	65 g for 8 milliseconds - half sine pulse
Vibration	TRANSIENT 16-35 cps at 0.35 inch D.A. 35-2000 cps at 22 g peak
Acoustics	See figures 3.8 and 3.9
Skin Temperature	No data available
Compartment Temperature	Not applicable

ZONE 7

3.11.3 FLIGHT PHASE

Shock	65 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-35 cps at 0.35 inch D.A. 35-2000 cps at 22 g peak	16-35 cps at 0.18 inch D.A. 35-2000 cps at 11 g peak
Acceleration	Maximum longitudinal acceleration 6.59 g Maximum lift-off acceleration 1.39 g	
Acoustics	See figures 3.8 and 3.9	
Skin Temperature	Aluminum skin of 45° fairing (0.046" al. covered with 0.04" Thermoloy T-230) +230°F maximum	
Compartment Temperature	NOTE: Spider beam is exposed to Lox during S-IV stage chill-down period.	

3.12 ZONE 8

3.12.1 TEST PHASE

Shock	65 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-35 cps at 0.35 inch D.A. 35-2000 cps at 22 g peak	16-35 cps at 0.18 inch D.A. 35-2000 cps at 11 g peak
Acoustics	No data available	
Compartment Temperature	No data available	

ZONE 8

3.12.2 LAUNCH PHASE

Shock	35 g for 8 milliseconds - half sine pulse			
Vibration	TRANSIENT 16 - 35 cps at 0.35 inch D.A. 35 - 2000 cps at 22g peak			
Acoustics	See figures 3.9 and 3.10			
Skin Temperature	Outer		Inner	
	Maximum	Minimum	Maximum	Minimum
	+160°F	-10°F	+120°F	-10°F
Compartment Temperature	+ 35°F to + 60°F air conditioned			

ZONE 8

3.12.3 FLIGHT PHASE

Shock	65 g for 8 milliseconds - half sine pulse			
Vibration	TRANSIENT		STEADY STATE	
	16-35 cps at 0.35 inch D.A. 35-2000 cps at 22 g peak		16-35 cps at 0.18 inch D.A. 35-2000 cps at 11 g peak	
Acceleration	S-I stage Maximum longitudinal acceleration 6.59 g S-IV stage Maximum longitudinal acceleration 5.62 g			
Acoustics	See figures 3.9 and 3.10			
Skin Temperature	Outer		Inner	
	Maximum	Minimum	Maximum	Minimum
	+255°F	-10°F	+215°F	-10°F
Compartment Temperature	- 250°F minimum during Lox chill-down + 150°F maximum			

3.13 ZONE 9

3.13.1 TEST PHASE

Shock	No data available
Vibration	No data available
Acoustics	No data available
Compartment Temperature	No data available

ZONE 9

3.13.2 LAUNCH PHASE

Shock	35 g for 8 milliseconds - half sine pulse
Vibration	TRANSIENT 20-55 cps at 5 g peak 55-110 cps at 0.03 inch D.A. 110-2000 cps at 20 g peak
Acoustics	See figures 3.9 and 3.10
Skin Temperature	Not applicable
Compartment Temperature	+ 35°F to + 60°F - air conditioned

ZONE 9

3.13.3 FLIGHT PHASE

Shock *	80 g for 8 milliseconds - half sine pulse	
Vibration *	TRANSIENT	STEADY STATE
	16-40 cps at 0.33 inch D.A. 40-100 cps at 27 g peak 100-114 cps at 0.053 in. D.A. 114-2000 cps at 35 g peak	16-40 cps at 0.17 inch D.A. 40-100 cps at 13.5 g peak 100-114 cps at 0.027 in. D.A. 114-2000 cps at 17.5 g peak
Acceleration	S-I stage Maximum longitudinal acceleration 6.59 g S-IV stage Maximum longitudinal acceleration 5.44 g	
Acoustics	See figures 3.9 and 3.10	
Skin Temperature	Not applicable	
Compartment Temperature	No data available	

* Values given are for S-IV Stage ignition and powered flight

ZONE 10

3.14.1 TEST PHASE

Shock	No data available
Vibration	No data available
Acoustics	No data available
Compartment Temperature	No data available

ZONE 10

3.14.2 LAUNCH PHASE

Shock	35 g for 8 milliseconds - half sine pulse			
Vibration	TRANSIENT 20-55 cps at 5 g peak 55-110 cps at 0.03 inch D.A. 110-2000 cps at 20 g peak			
Acoustics	See figures 3.9 and 3.10			
Skin Temperature	Outer		Inner	
	Maximum	Minimum	Maximum	Minimum
	+160°F	-40°F	+120°F	-40°F
Compartment Temperature	+ 35 to + 60°F - air conditioned			

ZONE 10

3.14.3 FLIGHT PHASE

Shock*	35 g for 8 milliseconds - half sine pulse			
Vibration *	TRANSIENT		STEADY STATE	
	16-42 cps at 2 g peak 42-95 cps at 0.022 inch D.A. 95-2000 cps at 10 g peak		16-42 cps at 1 g peak 42-95 cps at 0.011 inch D.A. 95-2000 cps at 5 g peak	
Acceleration	S-I stage Maximum longitudinal acceleration 6.59 g S-IV stage Maximum longitudinal acceleration 5.44 g			
Acoustics	See figures 3.9 and 3.10			
Skin Temperature	Outer		Inner	
	Maximum	Minimum	Maximum	Minimum
	+135°F	+135°F	-40°F	-40°F
Compartment Temperature	No data available			

*Values given are S-IV stage ignition and powered flight

3.15 ZONE 11 3.15.1 TEST PHASE	
Shock	No data available
Vibration	No data available
Acoustics	No data available
Compartment Temperature	No data available

ZONE 11

3.15.2 LAUNCH PHASE

Shock	35 g for 8 milliseconds - half sine pulse							
Vibration	TRANSIENT 20-55 cps at 5 g peak 55-110 cps at 0.03 inch D.A. 110-2000 cps at 20 g peak							
Acoustics	See figure 3.10							
Skin Temperature	Lox Dome Tank				Common Bulkhead			
	Outer		Inner		Outer		Inner	
	Max	Min	Max	Min	Max	Min	Max	Min
	+160°F	-297°F	+120°F	-297°F	+120°F		+120°F	-297°F
Compartment Temperature	+ 120°F to -297°F							

ZONE 11

3.15.3 FLIGHT PHASE

Shock*	35 g for 8 milliseocnds - half sine pulse							
Vibration*	TRANSIENT				STEADY STATE			
	16-42 cps at 2 g peak 42-95 cps at 0.022 inch D.A. 95-2000 cps at 10 g peak				16-42 cps at 1 g peak 42-95 cps at 0.011 inch D.A. 95-2000 cps at 5 g peak			
Acceleration	S-I stage Maximum longitudinal acceleration 6.59 g S-IV stage Maximum longitudinal acceleration 5.44 g							
Acoustics	See figure 3.10							
Skin Temperature	Lox Tank Dome				Common Bulkhead			
	Outer		Inner		Outer		Inner	
	Max	Min	Max	Min	Max	Min	Max	Min
	-200°F	-297°F	-200°F	-297°F	No data		-200°F	-297°F
Compartment Temperature	-297°F							

* Values given are for S-IV stage ignition and powered flight

3.16 ZONE 12

3.16.1 TEST PHASE

Shock	No data available
Vibration	No data available
Acoustics	No data available
Compartment Temperature	No data available

ZONE 12

3.16.2 LAUNCH PHASE

Shock	20 g for 8 milliseconds - half sine pulse
Vibration	TRANSIENT 20-50 cps at 2 g peak 50-110 cps at 0.016 inch D.A. 110-2000 cps at 10 g peak
Acoustics	See figures 3.10 and 3.11
Skin Temperature	Not applicable
Compartment Temperature	+ 120°F to - 423°F

ZONE 12

3.16.3 FLIGHT PHASE

Shock *	35 g for 8 milliseconds - half sine pulse	
Vibration *	TRANSIENT	STEADY STATE
	16-42 cps at 2 g peak 42-95 cps at 0.022 inch D.A. 95-2000 cps at 10 g peak	16-42 cps at 1 g peak 42-95 cps at 0.011 inch D.A. 95-2000 cps at 5 g peak
Acceleration	S-I stage Maximum longitudinal acceleration 6.59 g S-IV stage Maximum lognitudinal acceleration 5.44 g	
Acoustics	See figures 3.10 and 3.11	
Skin Temperature	Not applicable	
Compartment Temperature	- 423°F	

*Valves given are for S-IV stage ignition and powered flight

3.17 ZONE: 13

3.17.1 TEST PHASE

Shock	No data available
Vibration	No data available
Acoustics	No data available
Compartment Temperature	No data available

ZONE 13

3.17.2 LAUNCH PHASE

Shock	20 g for 8 milliseconds - half sine pulse			
Vibration	TRANSIENT 20-50 cps at 2 g peak 50-110 cps at 0.016 inch D.A. 110-2000 cps at 10 g peak			
Acoustics	See figures 3.10 and 3.11			
Skin Temperature	Outer		Inner	
	Maximum	Minimum	Maximum	Minimum
	+160°F	-86°F	+120°F	-86°F
Compartment Temperature	Not applicable			

ZONE 13

3.17.3 FLIGHT PHASE

<table>
<tr><td>Shock *</td><td colspan="4">35 g for 8 milliseconds - half sine pulse</td></tr>
<tr><td rowspan="2">Vibration *</td><td colspan="2">TRANSIENT</td><td colspan="2">STEADY STATE</td></tr>
<tr><td colspan="2">16-42 cps at 2 g peak
42-95 cps at 0.022 inch D.A.
95-2000 cps at 10 g peak</td><td colspan="2">16-42 cps at 1 g peak
42-95 cps at 0.011 inch D.A.
95-2000 cps at 5 g peak</td></tr>
<tr><td>Acceleration</td><td colspan="4">S-I stage
Maximum longitudinal acceleration 6.59 g
S-IV stage
Maximum longitudinal acceleration 5.44 g</td></tr>
<tr><td>Acoustics</td><td colspan="4">See figures 3.10 and 3.11</td></tr>
<tr><td rowspan="3">Skin Temperature</td><td colspan="2">Outer</td><td colspan="2">Inner</td></tr>
<tr><td>Maximum</td><td>Minimum</td><td>Maximum</td><td>Minimum</td></tr>
<tr><td>+140°F</td><td>-86°F</td><td>+140°F</td><td>-86°F</td></tr>
<tr><td>Compartment Temperature</td><td colspan="4">Not applicable</td></tr>
</table>

* Values given are for S-IV stage ignition and powered flight

3.18 ZONE 14

3.18.1 TEST PHASE

Shock	No data available
Vibration	No data available
Acoustics	No data available
Compartment Temperature	No data available

ZONE 14

3.18.2 LAUNCH PHASE

Shock	20 g for 8 milliseconds - half sine pulse							
Vibration	TRANSIENT 20-50 cps at 2 g peak 50-110 cps at 0.016 inch D.A. 110-2000 cps at 10 g peak							
Acoustics	See figures 3.11 and 3.12							
Skin Temperature	Forward Interstage				LH_2 Bulkhead			
	Outer		Inner		Outer		Inner	
	Max	Min	Max	Min	Max	Min	Max	Min
	+160°F	-10°F	+120°F	-10°F	+160°F	-86°F	+120°F	-86°F
Compartment Temperature	+ 3°F to + 86°F - air conditioned							

ZONE 14

3.18.3 FLIGHT PHASE

Shock *	35 g for 8 milliseconds - half sine pulse							
Vibration *	TRANSIENT				STEADY STATE			
	16-42 cps at 2 g peak 42-95 cps at 0.022 inch D.A. 95-2000 cps at 10 g peak				16-42 cps at 1 g peak 42-95 cps at 0.011 inch D.A. 95-2000 cps at 5 g peak			
Acceleration	S-I stage Maximum longitudinal acceleration 6.59 g S-IV stage Maximum longitudinal acceleration 5.44 g							
Acoustics	See figures 3.11 and 3.12							
Skin Temperature	Forward Interstage				LH_2 Bulkhead			
	Outer		Inner		Outer		Inner	
	Max	Min	Max	Min	Max	Min	Max	Min
	+500°F	-10°F	+400°F	-10°F	-86°F	-86°F	-86°F	-86°F
Compartment Temperature	+ 80°F to + 150°F							

* Values given are for S-IV stage ignition and powered flight

3.19 ZONE 15 3.19.1 TEST PHASE		
Shock	35 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-42 cps at 2 g peak 42-95 cps at 0.022 inch D.A. 95-2000 cps at 10 g peak	16-42 cps at 1 g peak 42-95 cps at 0.011 inch D.A. 95-2000 cps at 5 g peak
Acoustics	No data available	
Compartment Temperature	No data available	

ZONE 15

3.19.2 LAUNCH PHASE

Shock	15 g for 8 milliseconds - half sine pulse
Vibration	TRANSIENT 20-50 cps at 2 g peak 50-110 cps at 0.016 inch D.A. 110-2000 cps at 10 g peak
Acoustics	See figure 3.12
Skin Temperature	No data available
Compartment Temperature	Air Conditioned Instrument Canisters + 54°F to + 80°F Area external to canisters 50°F ± 30°F

ZONE 15

3.19.3 FLIGHT PHASE

Shock*	35 g for 8 milliseconds - half sine pulse	
Vibration*	TRANSIENT	STEADY STATE
	16-42 cps at 2 g peak 42-95 cps at 0.022 inch D.A. 95-2000 cps at 10 g peak	16-42 cps at 1 g peak 42-95 cps at 0.011 inch D.A. 95-2000 cps at 5 g peak
Acceleration	S-I stage Maximum longitudinal acceleration 6.59 g S-IV stage Maximum longitudinal acceleration 5.44 g	
Acoustics	See figure 3.12	
Skin Temperature	Maximum + 195°F (0.156 inch al.)	
Compartment Temperature	Air Conditioned Instrument canisters + 77°F ± 20°F Area external to canisters + 80°F to + 150°F	

* Values given are for S-IV stage ignition and powered flight

3.20 ZONE 16

3.20.1 TEST PHASE

Shock	35 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-42 cps at 2 g peak 42-95 cps at 0.022 inch D.A. 95-2000 cps at 10 g peak	16-42 cps at 1 g peak 42-95 cps at 0.011 inch D.A. 95-2000 cps at 5 g peak
Acoustics	No data available	
Compartment Temperature	No data available	

ZONE 16

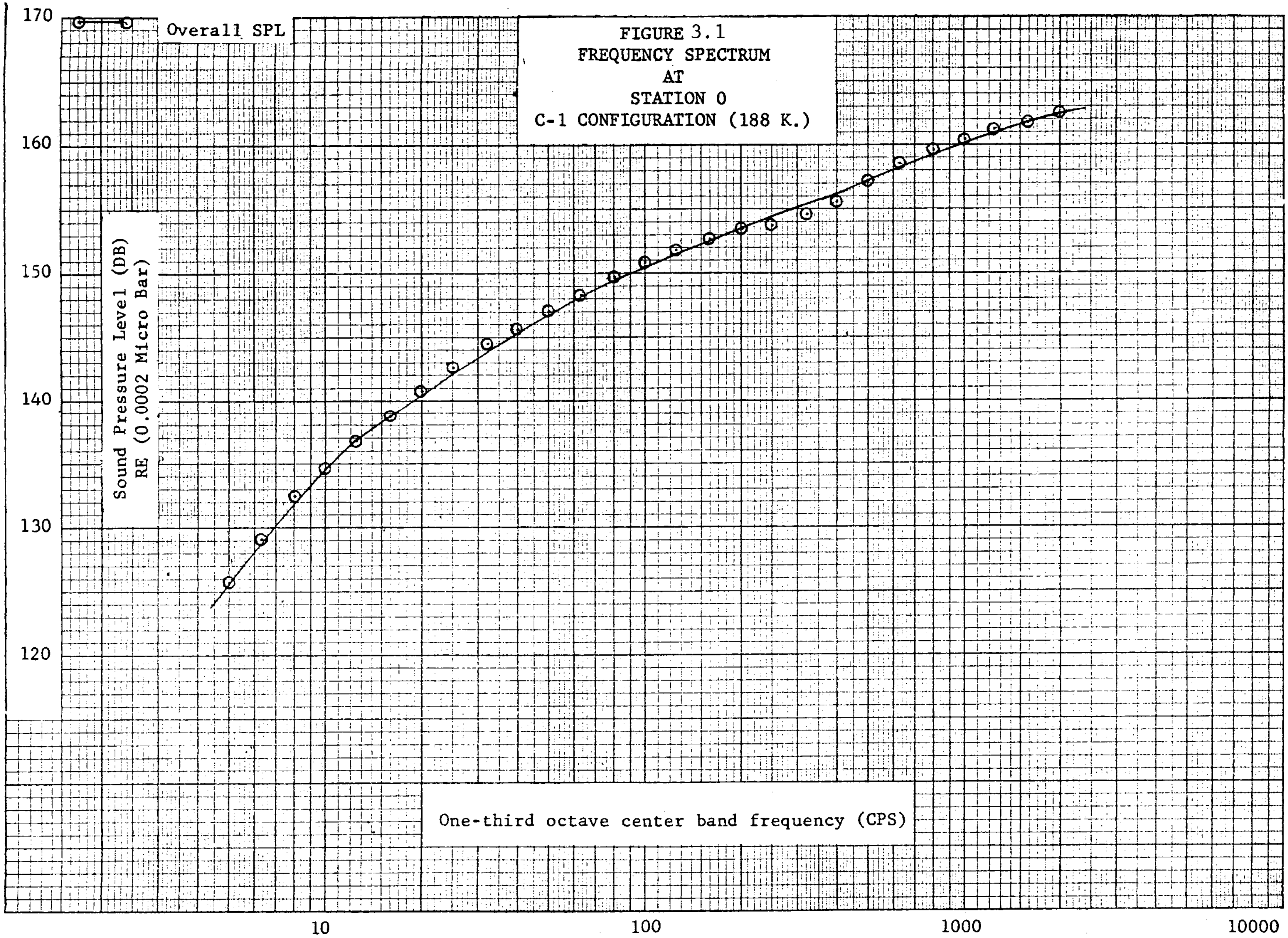
3.20.2 LAUNCH PHASE

Shock	15 g for 8 milliseconds - half sine pulse
Vibration	TRANSIENT 20-50 cps at 2 g peak 50-110 cps at 0.016 inch D.A. 110-2000 cps at 10 g peak
Acoustics	See figure 3.12
Skin Temperature	No data available
Compartment Temperature	No data available

ZONE 16

3.20.3 **FLIGHT PHASE**

Shock	35 g for 8 milliseconds - half sine pulse	
Vibration	TRANSIENT	STEADY STATE
	16-42 cps at 2 g peak 42-95 cps at 0.022 inch D.A. 95-2000 cps at 10 g peak	16-42 cps at 1 g peak 42-95 cps at 0.011 inch D.A. 95-2000 cps at 5 g peak
Acceleration	S-I stage Maximum longitudinal acceleration 6.59 g S-IV stage Maximum longitudinal acceleration 5.44 g	
Acoustics	See figure 3.12	
Skin Temperature	No data available	
Compartment Temperature	No data available	



Overall SPL
FIGURE 3.1
FREQUENCY SPECTRUM
AT
STATION 0
C-1 CONFIGURATION (188 K.)
Sound Pressure Level (DB)
RE (0.0002 Micro Bar)
170
160
150
140
130
120
10
100
1000
10000
One-third octave center band frequency (CPS)

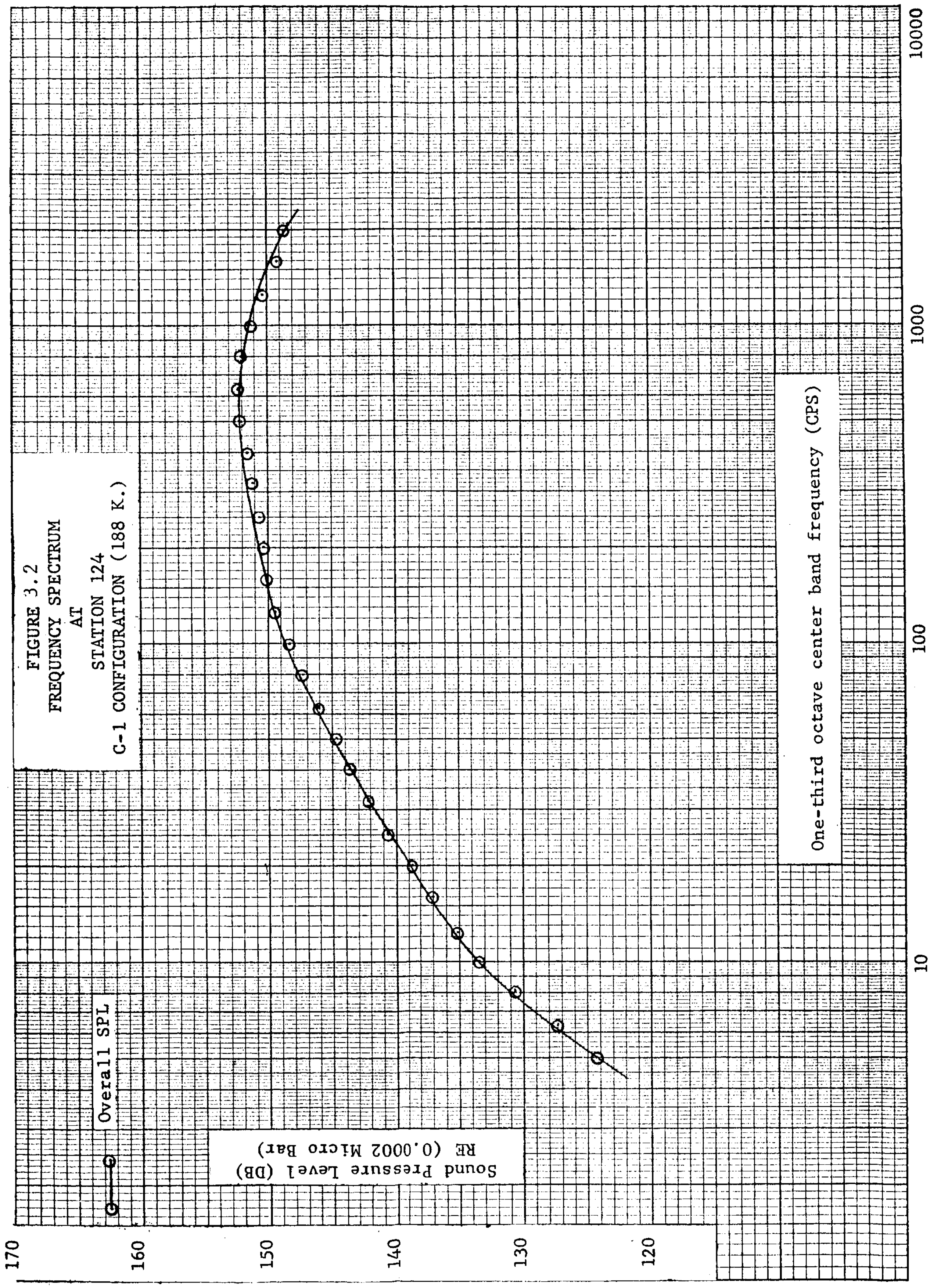


FIGURE 3.2
FREQUENCY SPECTRUM
AT
STATION 124
C-1 CONFIGURATION (188 K.)

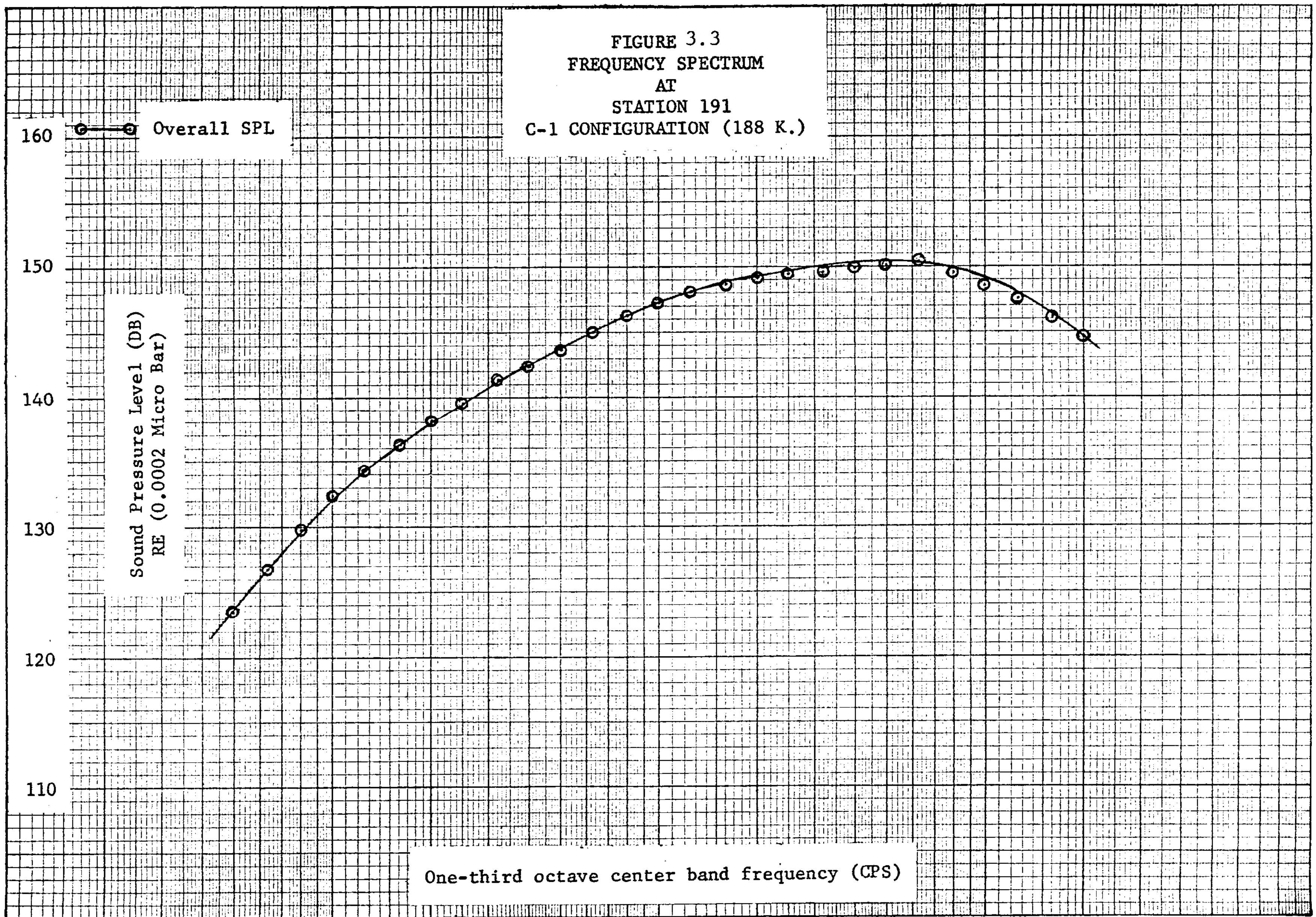


FIGURE 3.3
FREQUENCY SPECTRUM
AT
STATION 191
C-1 CONFIGURATION (188 K.)
Overall SPL
Sound Pressure Level (DB)
RE (0.0002 Micro Bar)
160
150
140
130
120
110
One-third octave center band frequency (CPS)
10
100
1000
10000

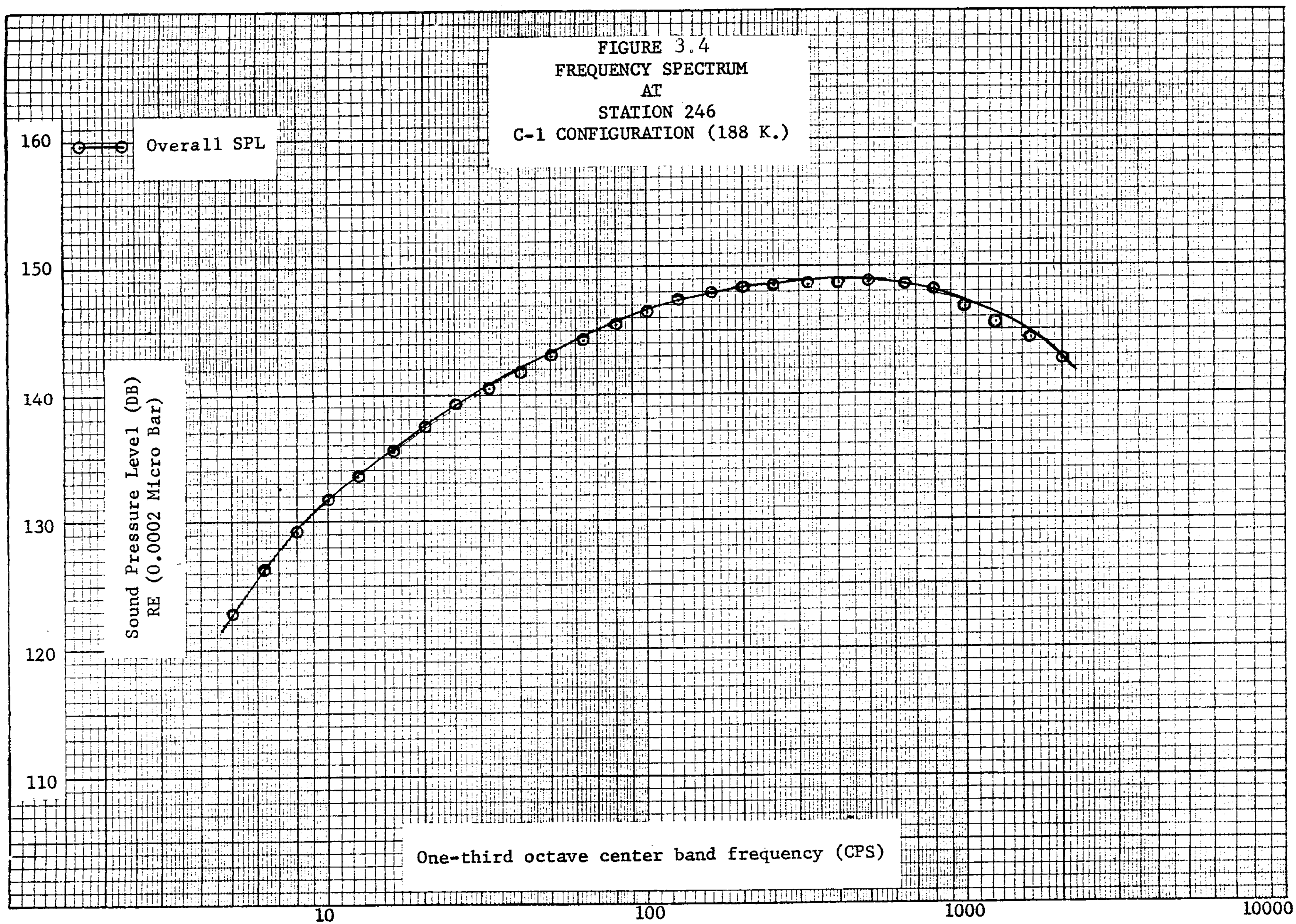


FIGURE 3.4
FREQUENCY SPECTRUM
AT
STATION 246
C-1 CONFIGURATION (188 K.)

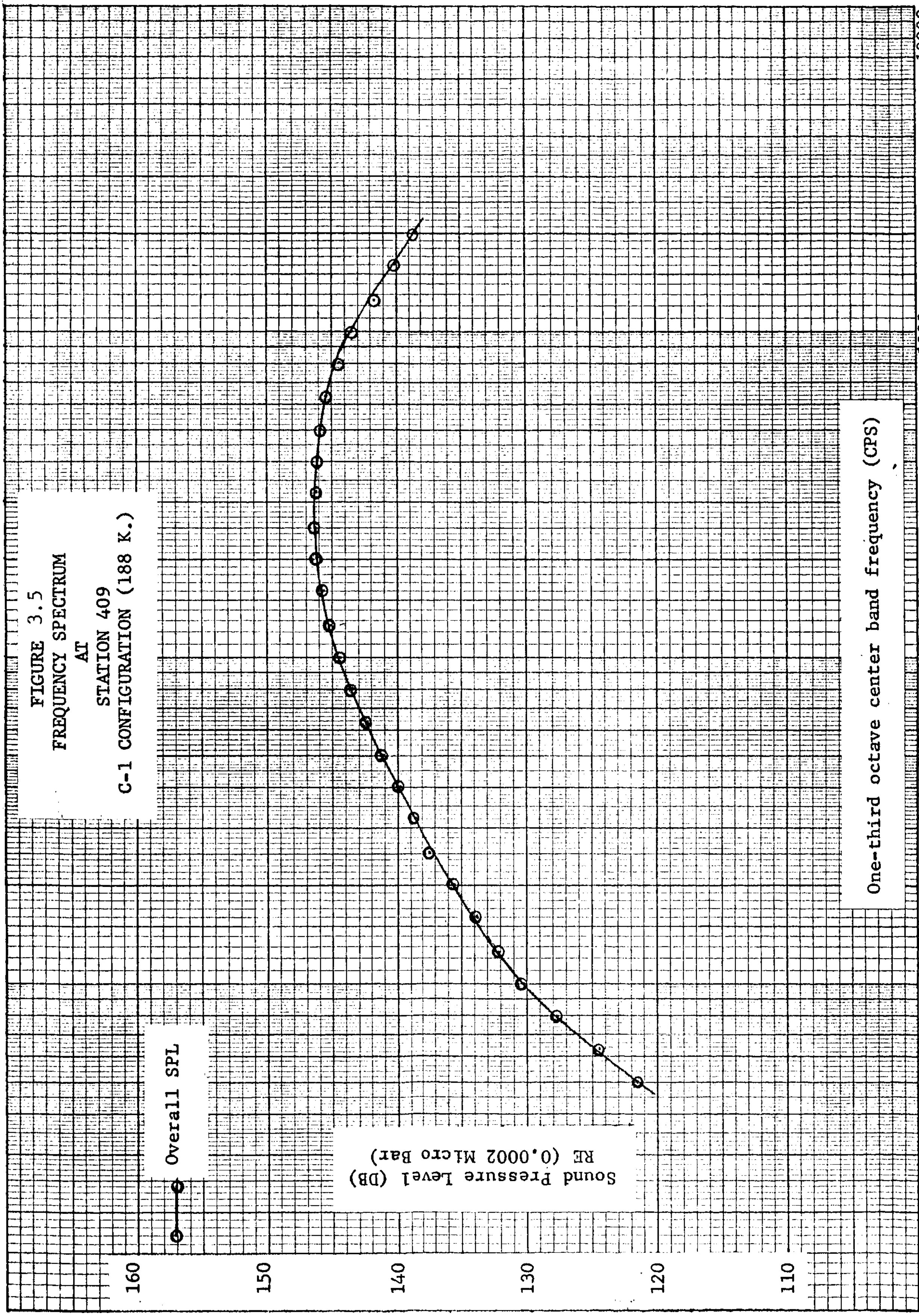


FIGURE 3.5
FREQUENCY SPECTRUM
AT
STATION 409
C-1 CONFIGURATION (188 K.)

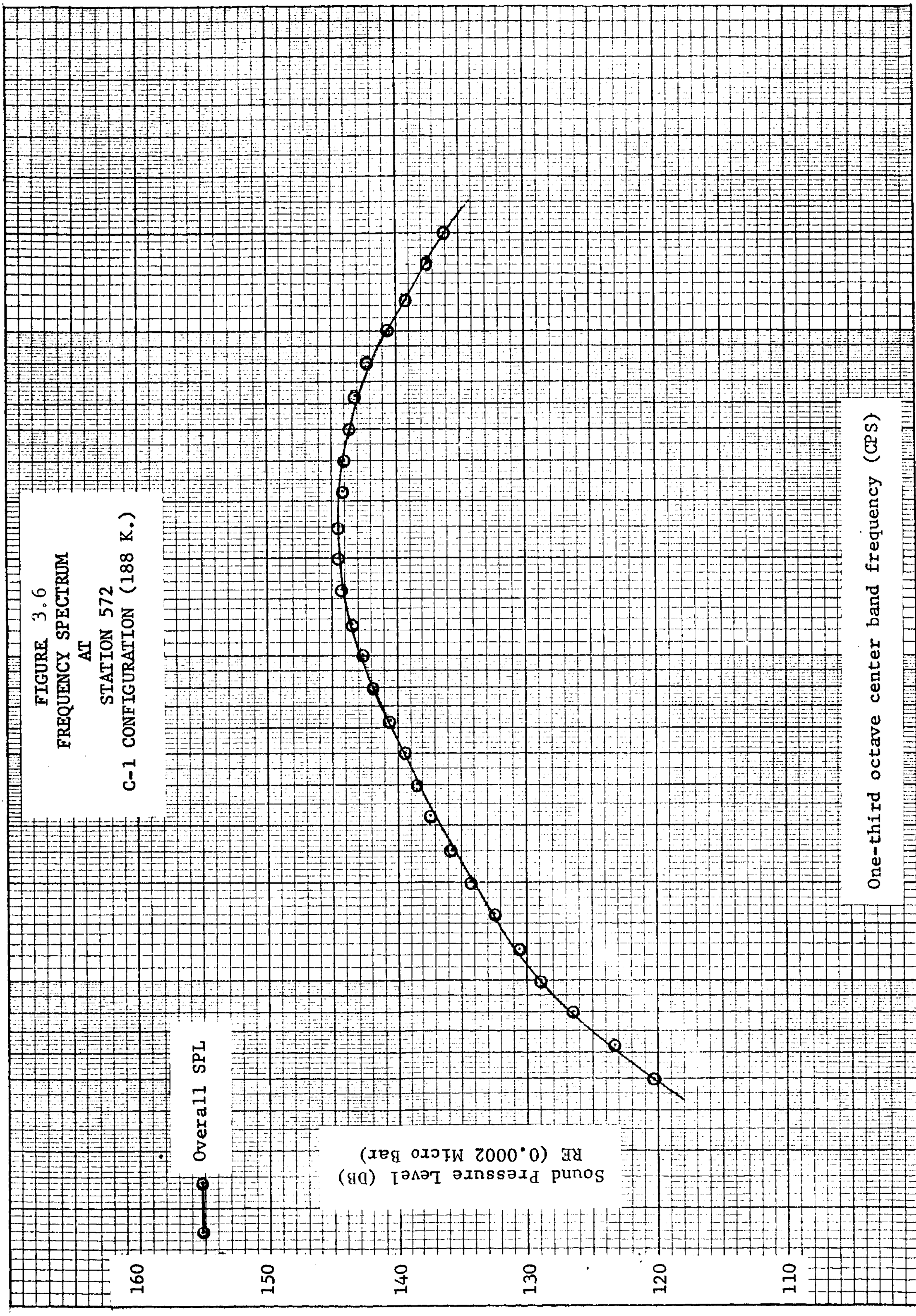


FIGURE 3.6
FREQUENCY SPECTRUM
AT
STATION 572
C-1 CONFIGURATION (188 K.)

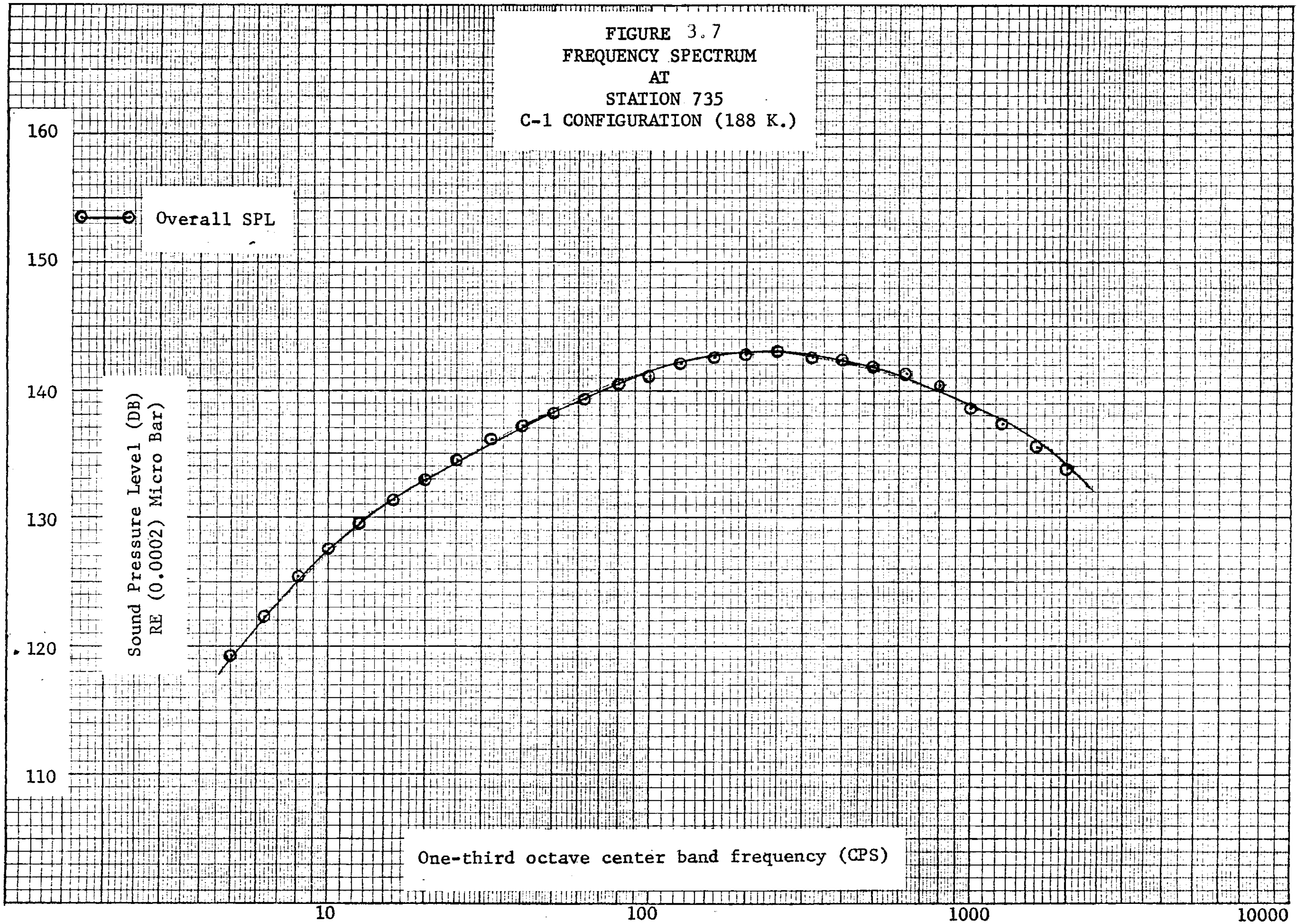


FIGURE 3.7
FREQUENCY SPECTRUM
AT
STATION 735
C-1 CONFIGURATION (188 K.)

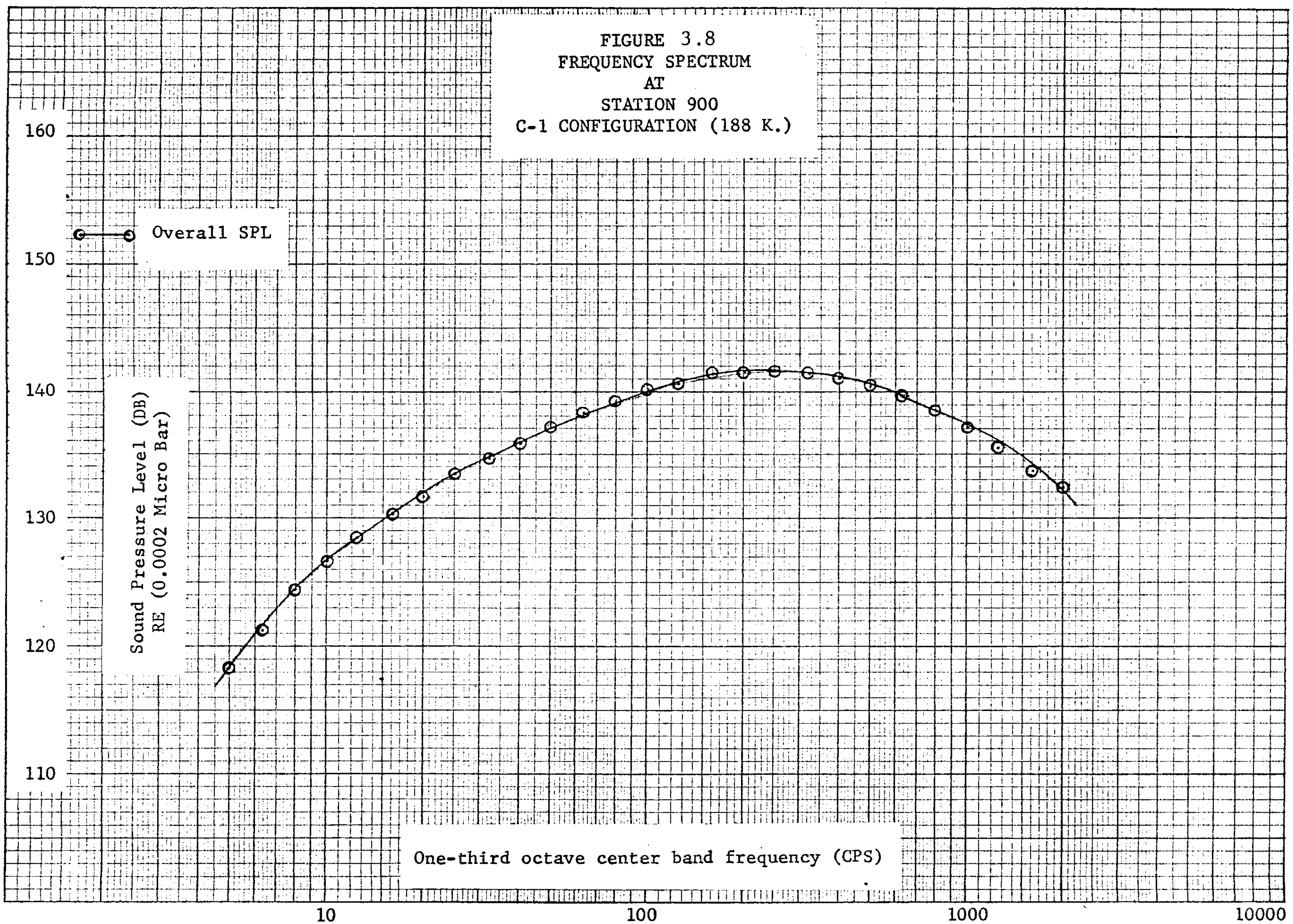
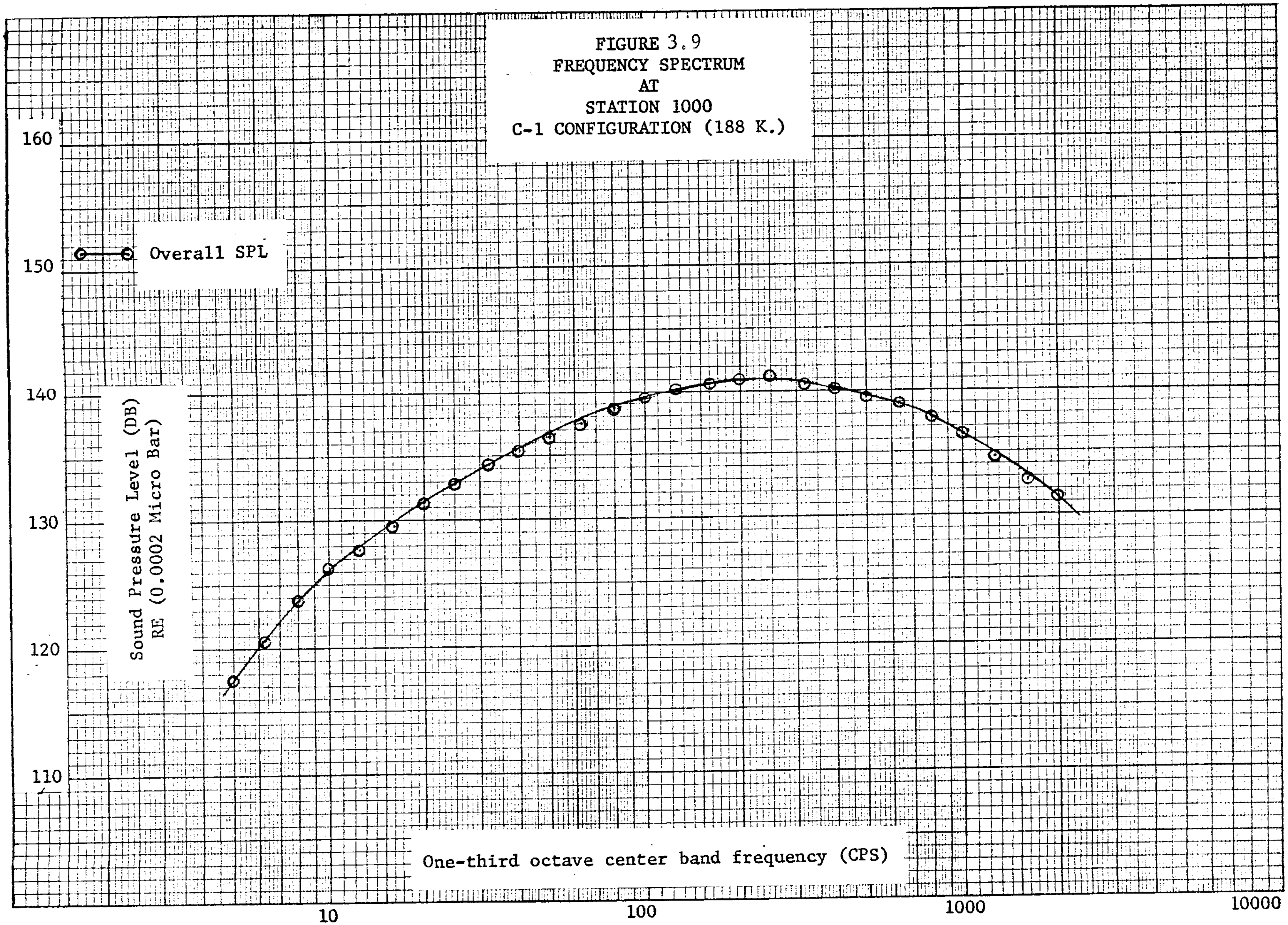


FIGURE 3.8
FREQUENCY SPECTRUM
AT
STATION 900
C-1 CONFIGURATION (188 K.)
Overall SPL
Sound Pressure Level (DB)
RE (0.0002 Micro Bar)
160
150
140
130
120
110
10
100
1000
10000
One-third octave center band frequency (CPS)

FIGURE 3.9
FREQUENCY SPECTRUM
AT
STATION 1000
C-1 CONFIGURATION (188 K.)



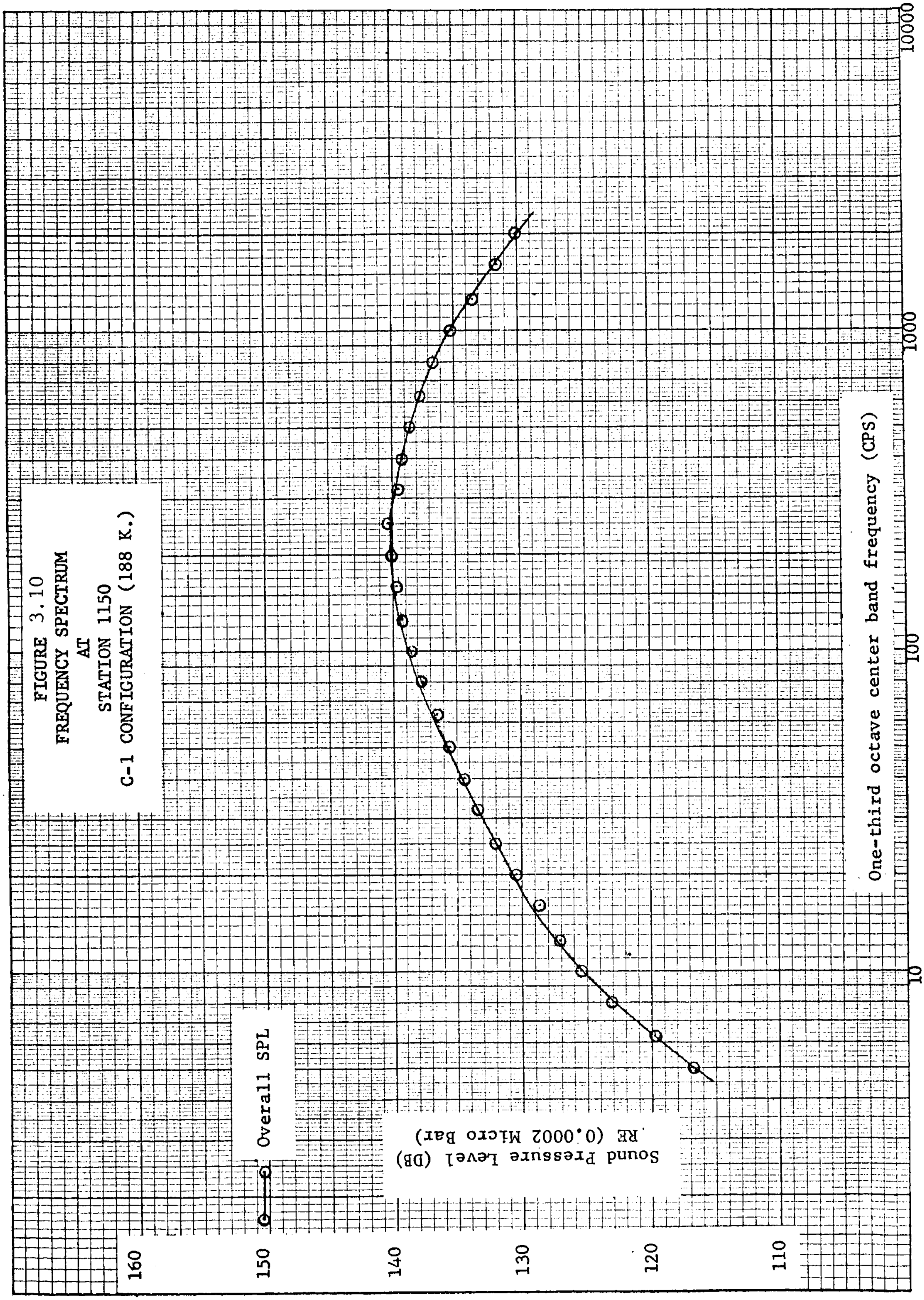


FIGURE 3.10
FREQUENCY SPECTRUM
AT
STATION 1150
C-1 CONFIGURATION (188 K.)

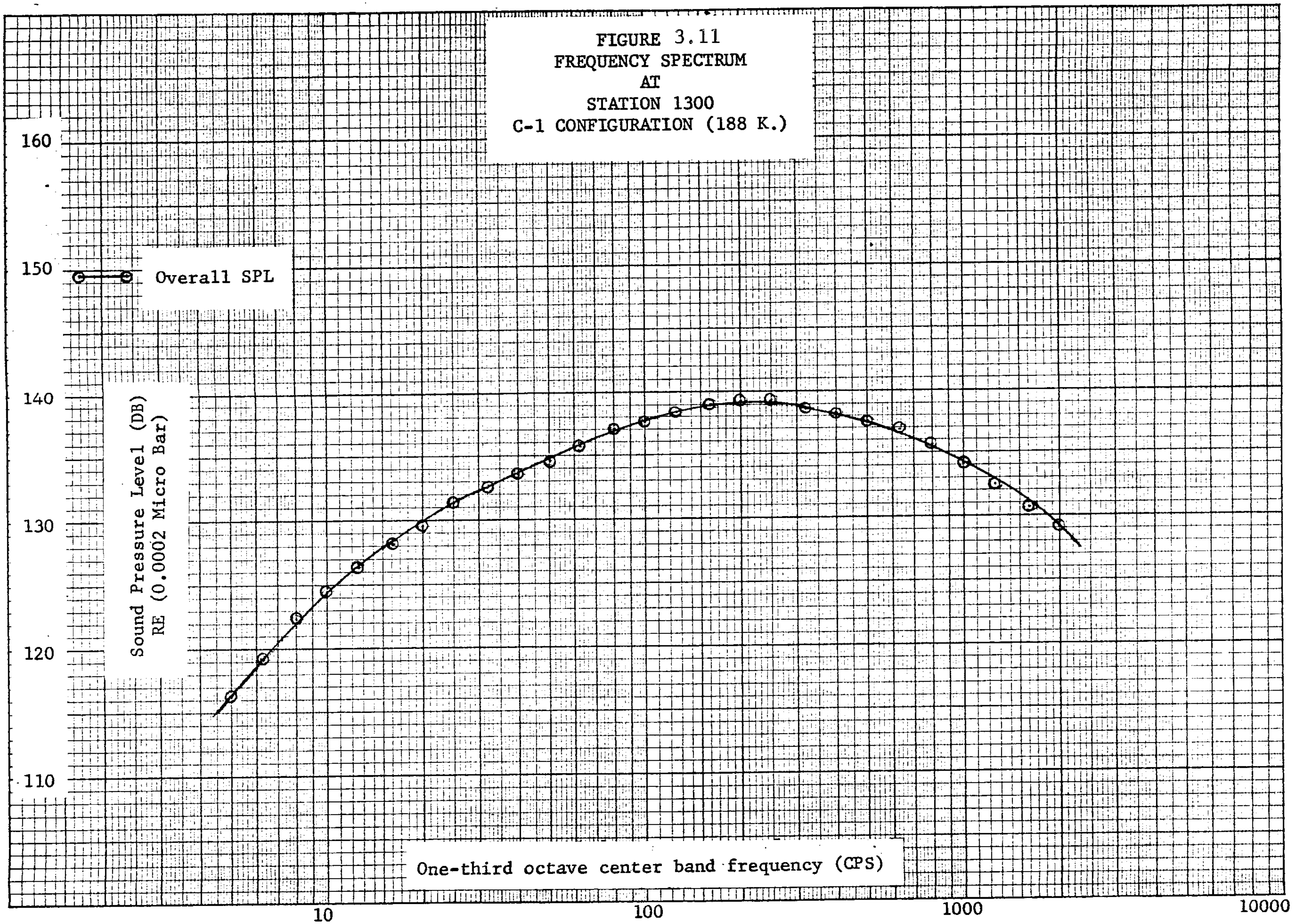


FIGURE 3.11
FREQUENCY SPECTRUM
AT
STATION 1300
C-1 CONFIGURATION (188 K.)
Overall SPL
Sound Pressure Level (DB)
RE (0.0002 Micro Bar)
160
150
140
130
120
110
10
100
1000
10000
One-third octave center band frequency (CPS)

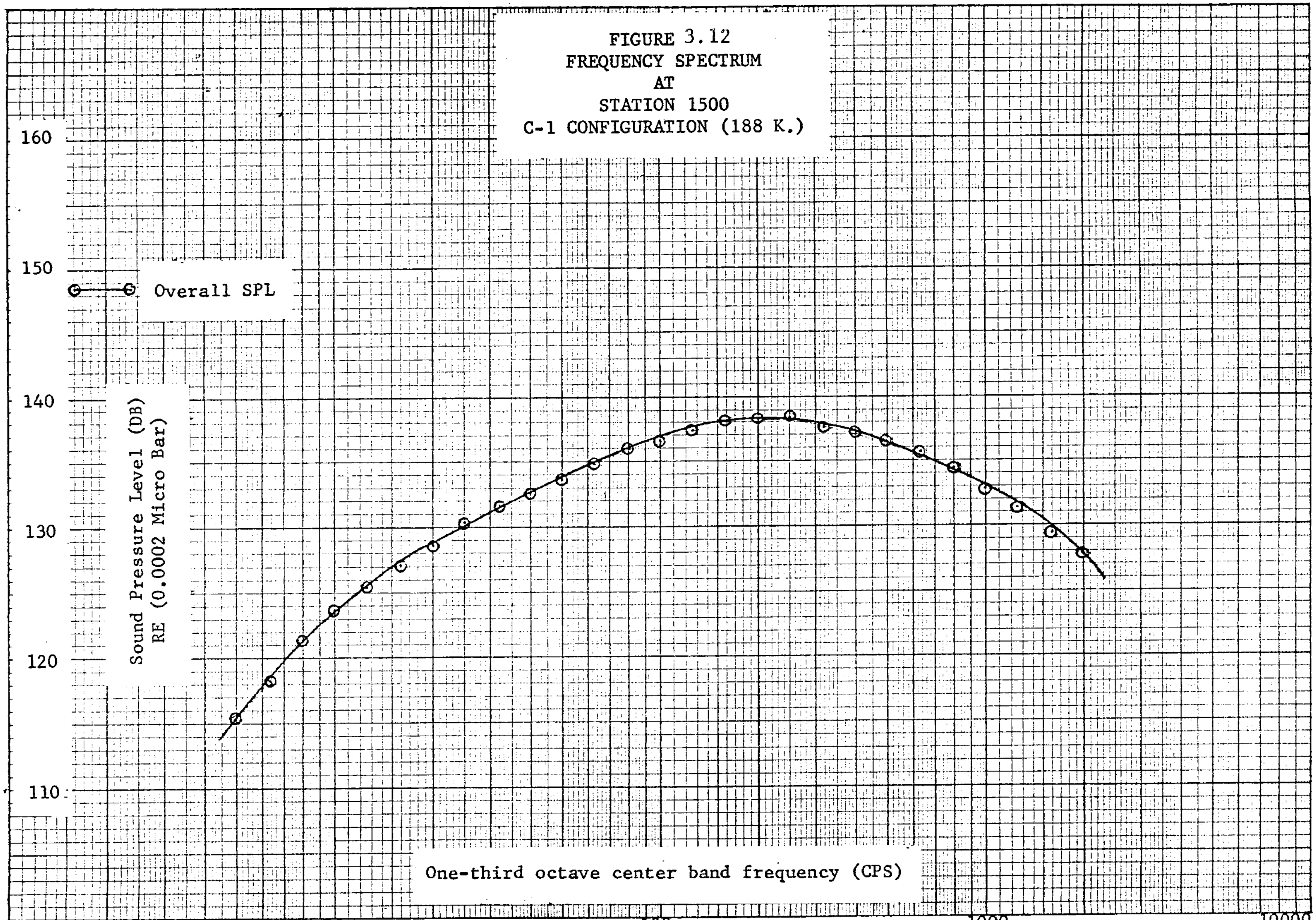
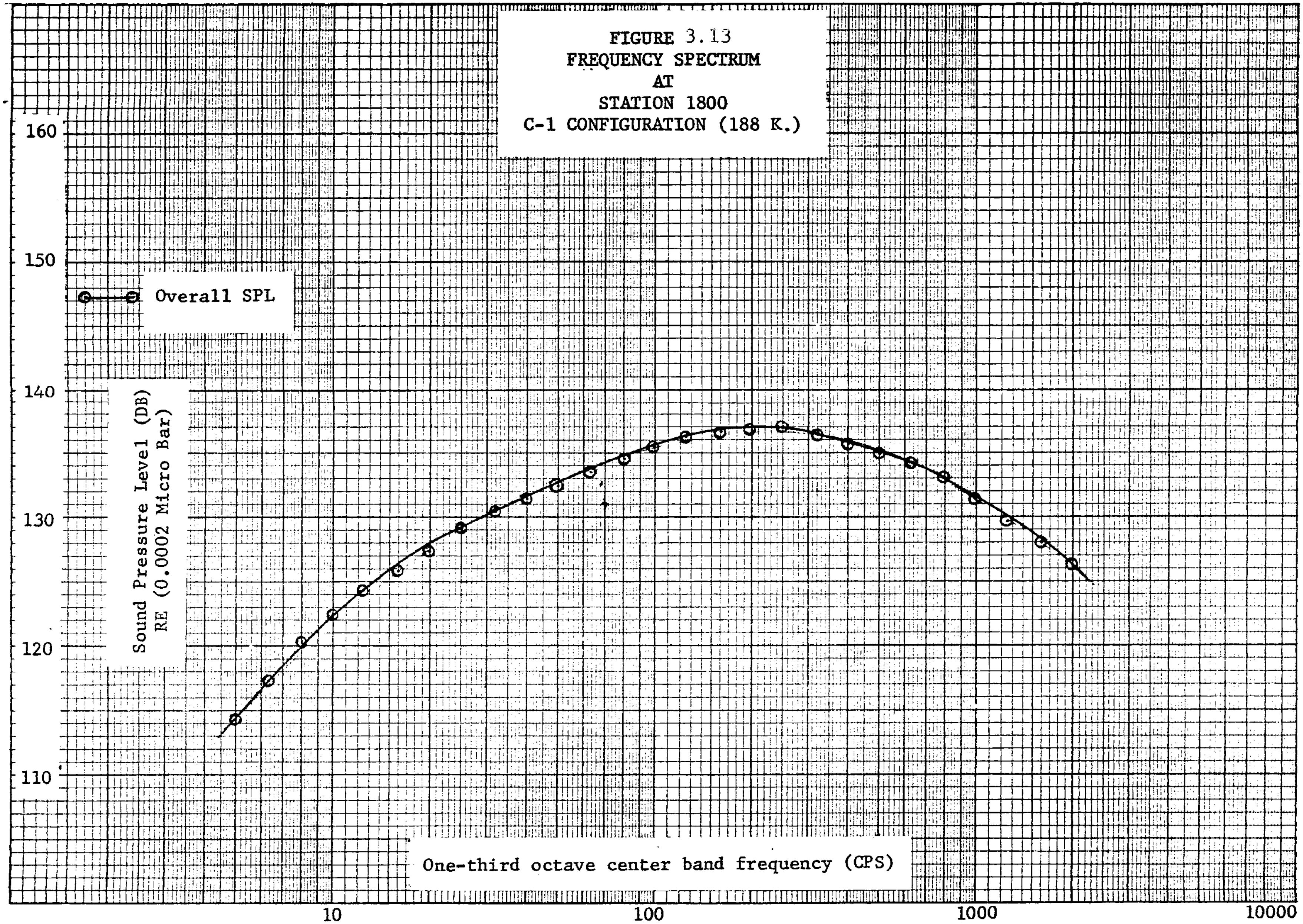


FIGURE 3.12
FREQUENCY SPECTRUM
AT
STATION 1500
C-1 CONFIGURATION (188 K.)
Overall SPL
Sound Pressure Level (DB)
RE (0.0002 Micro Bar)
160
150
140
130
120
110
One-third octave center band frequency (CPS)
10
100
1000
10000

FIGURE 3.13
FREQUENCY SPECTRUM
AT
STATION 1800
C-1 CONFIGURATION (188 K.)



SECTION IV

LAUNCH COMPLEX
INDUCED ENVIRONMENTS

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SECTION IV
LAUNCH COMPLEX INDUCED ENVIRONMENTS

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LIST OF ILLUSTRATIONS

SECTION IV

4.1 INDUCED ENVIRONMENT FOR LAUNCH COMPLEX 37 DUE TO THE SATURN VEHICLE

4.1.1 Introduction - This section consists of the antitipated acoustic and thermal induced environments for launch complex 37 during the launch and flight phases of the Saturn vehicle. The data will apply for complex 34 when it is modified to accommodate the Block II vehicles. In defining the acoustic environment, a set of tables and a drawing of the launch complex are used. For the acoustic and the thermal data, the values presented are based on eight 188,000 pound thrust engines using a bilateral blast deflector. The acoustic levels specified in the tables are the anticipated overall sound pressure levels (SPLoa) in decibels (db) (Ref. 0.0002 dynes/cm^2). All radial distances are measured from the vertical axis of the vehicle, launch pad "B". The natural environments to which the support equipment will be exposed are given in Section II.

4.1.2 Acoustic Environmental Data - The results of the acoustical analysis of launch complex 37 show that the sound pressure level profile is symmetrical about both horizontal centerlines of the bilateral exhaust deflector. For this reason, the angular measurements in Table 4.1 through Table 4.4 are measured from either exhaust stream in either direction from 0° to 180°. The acoustic levels in Table 4.1 through Table 4.4 are given in one decibel increments measured on radius lines every 10 degrees around the launch complex. Table 4.1 through Table 4.4 can be used to determine the overall sound pressure level of pad "B" during the launch phase, up to radii of approximately 2600 feet, measured from the vehicle vertical axis.

The results in Table 4.5 are the overall sound pressure levels, during the launch phase, for the major items of ground support equipment and launch facilities already located on launch complex 37 and pad "B" in particular.

The results in Table 4.6 are the maximum expected sound pressure levels due to the flight of the vehicle for the same equipment as listed in Table 4.5. This values do not occur simultaneously. They occur at some definite vehicle altitude and should be considered present only for a small time duration.

The results in Table 4.7 are the maximum anticipated sound pressure levels for the early flight phase (up to 2000 feet altitude) of the Saturn vehicle. The analysis indicates that as the vehicle lifts off the pad and continues to gain altitude, a circular pattern of sound pressure level distribution is generated from the center of launch pad "B". The maximum levels expected should occur only along the periphery of a circle at a radius corresponding to one specific vehicle altitude. At radii of greater or lesser value than the

4.1.2 Cont'd

specified value, the sound pressure value will be less than the maximum value given in the table. When applying the data in Table 4.7, consideration should be given to the fact that since the maximum values listed correspond to a specific vehicle altitude they are only present for a small time duration.

4.1.3 Thermal Environment

No data available.

FIGURE 4.1
PLAN VIEW OF COMPLEX 37

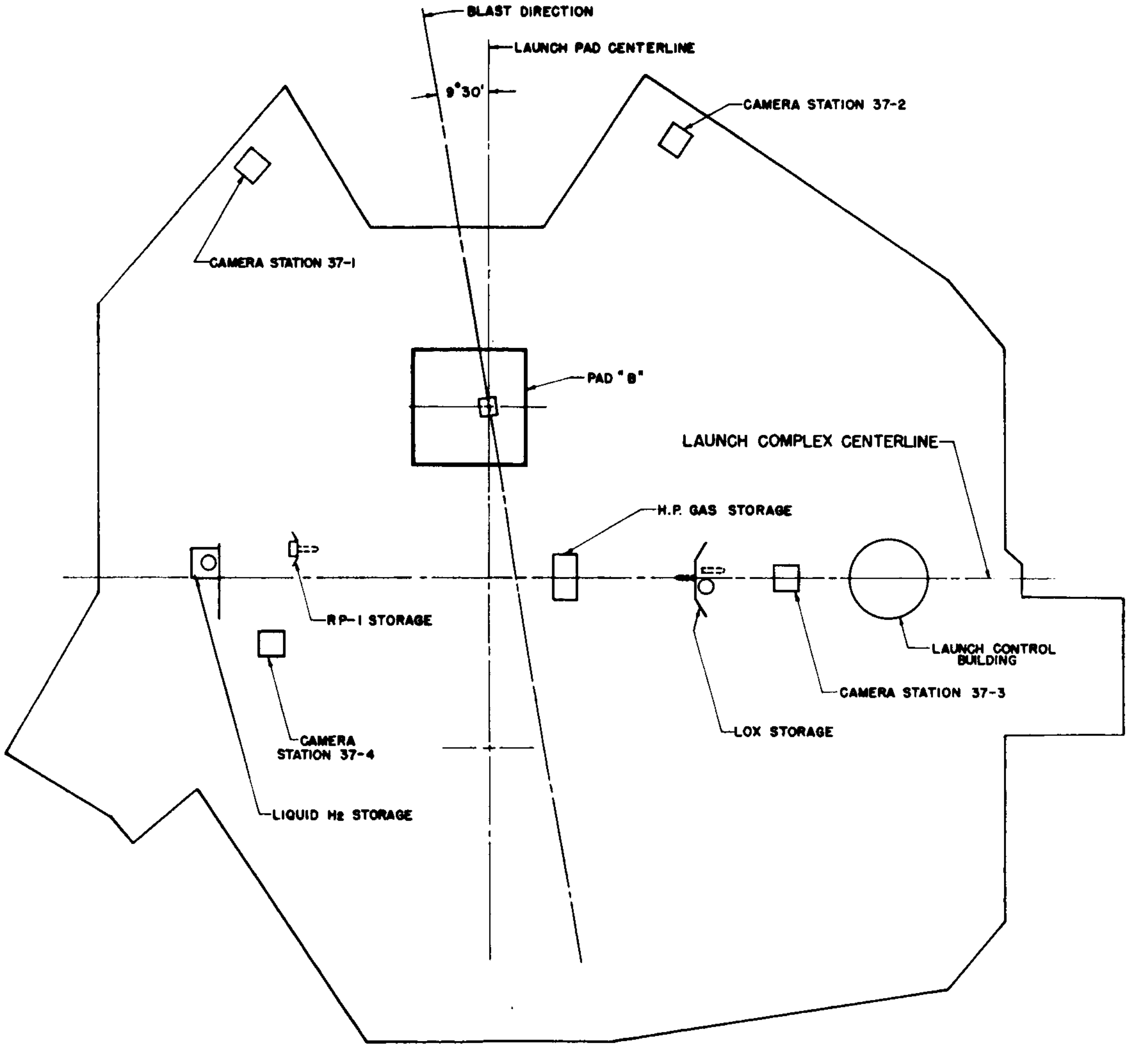

Table 4.1

SPL_{oa} for Different Radii and Different Angles from Exhaust Direction

Radii (ft) Angle (deg) SPL_{oa} (db) Ref. 0.0002 dynes/cm^2

Degrees	SPL_{oa} 130 db	131	132	133	134	135	136	137	138	139	140	
0 - 180	1390 ft	1240	1102	983	876	782	696	621	553	493	439	R
10 - 170	1556	1390	1235	1103	981	876	781	695	619	552	492	A
20 - 160	1970	1759	1564	1397	1242	1109	989	880	785	699	623	D
30 - 150	2500	2230	1985	1773	1579	1406	1254	1119	995	887	791	I
40 - 140	2610	2320	2067	1840	1640	1462	1305	1162	1037	923	822	I
50 - 130	2500	2230	1985	1773	1579	1406	1254	1119	995	887	791	
60 - 120	2160	1930	1716	1532	1362	1217	1084	966	860	767	684	
70 - 110	1798	1603	1428	1276	1135	1011	902	805	716	638	568	
80 - 100	1647	1470	1308	1169	1038	928	825	733	655	585	521	
90 - 90	1582	1415	1256	1123	1000	892	795	708	631	562	501	

Table 4.2

SPL_{oa} for Different Radii and Different Angles from Exhaust Direction

Radii (ft) Angle (deg) SPL_{oa} (db) Ref. 0.0002 dynes/cm^2

Degrees	SPL_{oa} 141 db	142	143	144	145	146	147	148	149	150	
0 - 180	392 ft	349	311	278	247	210	197	171	156	139	R
10 - 170	439	391	348	311	277	247	220	196	175	156	A
20 - 160	556	495	441	393	350	313	279	248	221	197	D
30 - 150	706	628	560	500	444	397	454	315	281	250	I
40 - 140	734	654	583	520	463	413	468	327	292	261	I
50 - 130	706	628	560	500	444	397	454	315	281	250	
60 - 120	610	543	484	432	385	343	306	272	242	217	
70 - 110	507	452	403	360	320	285	255	226	202	180	
80 - 100	465	414	369	329	293	262	233	207	185	165	
90 - 90	446	398	355	316	282	251	224	199	178	159	

Table 4.3

SPL_{oa} for Different Radii and Different Angles from Exhaust Direction

Radii (ft) Angle (deg) SPL_{oa} (db) Ref. 0.0002 dynes/cm^2

Degrees	SPL_{oa} 151 db	152	153	154	155	156	157	158	159	160	
0 - 180	124 ft	110	98	87	78	70	62	55	49	44	R
10 - 170	139	124	110	98	88	78	70	62	55	49	A
20 - 160	176	156	140	124	111	99	88	79	70	62	D
30 - 150	223	199	177	158	141	125	112	100	89	79	I
40 - 140	232	207	184	164	146	131	116	104	92	82	I
50 - 130	223	199	177	158	141	125	112	100	89	79	
60 - 120	193	172	153	136	122	108	97	86	77	68	
70 - 110	160	143	128	114	101	90	81	72	64	57	
80 - 100	147	131	117	104	93	83	73	66	59	52	
90 - 90	141	126	112	100	89	80	71	63	56	50	

Table 4.4

SPL_{oa} for Different Radii and Different Angles from Exhaust Direction

Radii (ft) Angle (deg) SPL_{oa} (db) Ref. 0.0002 dynes/cm2

Degrees	SPL_{oa} 161 db	162	163	164	165	166	167	168	169	170	
0 - 180	39 ft	35	31	28	25	21	20	17	16	14	R
10 - 170	44	39	35	31	28	25	22	20	18	16	A
20 - 160	56	50	44	39	35	31	28	25	22	20	D
30 - 150	71	63	56	50	44	40	45	32	28	25	I
40 - 140	73	65	58	52	46	41	47	33	29	26	I
50 - 130	71	63	56	50	44	40	45	32	28	25	
60 - 120	61	54	48	43	39	34	31	27	24	22	
70 - 110	51	45	40	36	32	29	26	23	20	18	
80 - 100	47	41	37	33	29	26	23	21	19	17	
90 - 90	45	40	36	32	28	25	22	20	18	16	

Table 4.5
Maximum SPL_{oa} for Major Ground Support Equipment
and Facilities During Launch Phase (Pre-Lift-off)

Identification	Location from Vehicle Axis (ft)	SPL_{oa} (db) Ref. 0.0002 dynes/cm^2
1. Launch Pedestal	0	*
2. Umbilical Tower	58	159.7
3. Automatic Ground Control Station	110	154.4
4. Periphery Camera Pad B-1	250	150.8
5. Periphery Camera Pad B-4	250	149.6
6. Periphery Camera Pad B-2	285	149.4
7. Periphery Camera Pad B-3	285	149.5
8. Generator Pad	300	145.1
9. Power Pedestal Pad	340	148.1
10. Cooling Tower	420	144.0
11. H.P. Gas Storage Area	500	141.5
12. RP-1 Storage Area	680	138.3
13. Lox Storage Area	740	139.3
14. LH_2 Storage Area	875	136.6
15. Camera Station 37-2	875	139.8
16. Camera Station 37-4	875	139.3
17. Camera Station 37-1	930	139.3
18. Camera Station 37-3	930	139.0
19. Electrical Equipment Bldg. "B"	960	135.1
20. Launch Control Bldg.	1175	136.2
21. Operations Support Bldg.	1645	133.4

*No value listed because of particle impingement in the immediate exhaust stream

Table 4.6
Maximum SPL_{oa} for Major Ground Support Equipment
and Facilities During Flight Phase (After Lift-off)

	Identification	SPL_{oa} (db) Ref. 0.0002 dynes/cm^2
1.	Launch Pedestal	*
2.	Umbilical Tower	157.3
3.	Automatic Ground Control Station	151.8
4.	Periphery Camera Pad B-1	144.7
5.	Periphery Camera Pad B-4	144.7
6.	Periphery Camera Pad B-2	143.5
7.	Periphery Camera Pad B-3	143.5
8.	Generator Pad	142.9
9.	Power Pedestal Pad	142.0
10.	Cooling Tower	140.2
11.	H.P. Gas Storage Area	138.7
12.	RP-1 Storage Area	136.0
13.	Lox Storage Area	135.3
14.	LH_2 Storage Area	133.8
15.	Camera Station 37-2	133.8
16.	Camera Station 37-4	133.8
17.	Camera Station 37-1	133.3
18.	Camera Station 37-3	133.3
19.	Electrical Equipment Bldg. "B"	133.0
20.	Launch Control Bldg.	131.2
21.	Operations Support Bldg.	128.3

*No value listed because of particle impingement in the immediate exhaust stream.

Table 4.7
Launch Complex 37, Maximum SPL_{oa} for Various Vehicle Altitudes
(After Lift-Off)

Altitude of nozzle exit plane (feet)	Radial Distance from Vehicle Vertical Axis (ft)	Max SPL_{oa} (db) Ref. 0.002 dynes/cm^2
80	67.3	156.1
90	75.6	155.1
100	84.0	154.2
120	100.7	152.6
140	117.7	151.7
160	134.6	150.1
180	151.5	149.1
200	168.0	148.1
250	210.0	146.2
300	252.0	144.6
350	294.0	143.3
400	336.1	142.1
500	420.0	140.2
600	504.0	138.6
750	630.0	136.7
1000	840.0	134.2
1500	1257.0	130.6
2000	1680.0	128.3